AMERICAN ENGINEER AND RAILROAD JOURNAL.

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"NORTHWESTERN TYPE" PASSENGER LOCOMOTIVE.

Chicago & Northwestern Railway.

Comparison with Standard Passenger Engines on New York Central.

The new wide firebox passenger engines for the Chicago & Northwestern, built last summer by the Schenectady Locomotive Works, and called "Northwestern Type," are specially interesting and the design is believed to be an important one which is likely to exert a strong influence toward wide fireboxes for soft coal. We illustrated the engine on page 237 of our August number, and by courtesy of Mr. Quayle and the builders we are now permitted to direct attention to some of the important details.

The results of the service so far obtained seem to indicate that this design is a step in the right direction. The reports which we have seen are entirely satisfactory. The engines perform their work with ease and with an increase of comfort to the fireman in maintaining steam pressure. They are almost smokeless, even when burning western coals. Perhaps the two fire doors contribute to this, but it seems clear that the large grate makes it possible to secure advantageous conditions of combustion which are unusual in locomotives burning soft coal.

Before being delivered to the owners one of these engines was "broken in" on the New York Central, and the opportunity was taken to compare it with one of the regular "Empire State Express" engines, an 8-wheel type, and with one of the heavy 10-wheel passenger engines, No. 2,012. The three engines were pooled on two trains, Nos. 18 and 51, for five days, with the results given in the accompanying table, which Mr. A. M. Waitt of the New York Central has kindly supplied us:

Locomotives Compared on the New York Central.

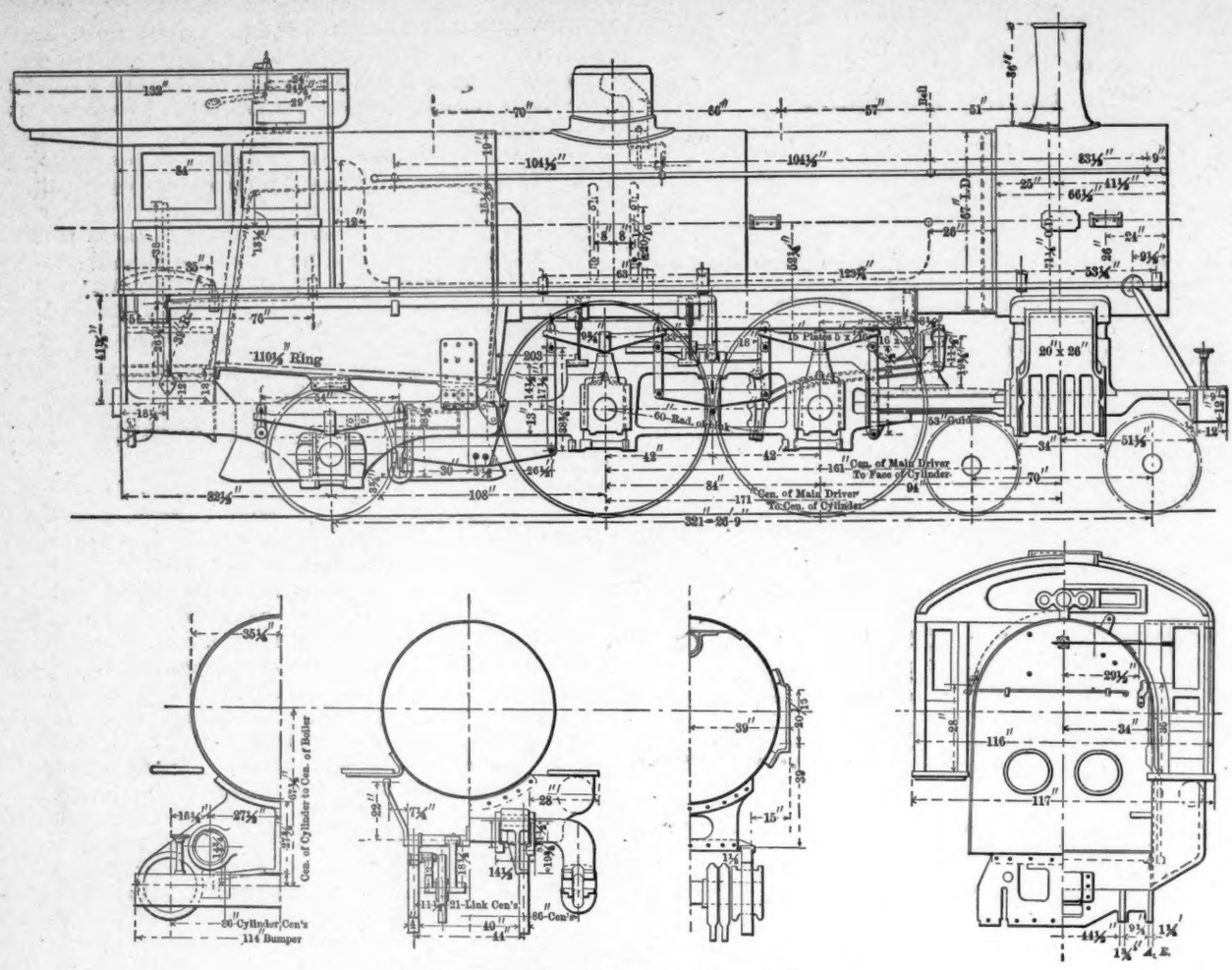
Engines.	N. Y. C. No. 870.	N. W.	N. Y. C. No. 2012.
Type	8-wheel.	Northwestern.	10-wheel.
Weight in working order	131,000 lbs.	160,000 lbs.	168,900 lbs.
Cylinders	19x24	20x26	20x28
Drivers	70 in.	80 in	75 in.
Heating surface	1,974 sq. ft.	3,015 sq. ft.	2,908 sq. ft.
Grate area	30.7 sq. ft.	46.2 sq. ft.	30.5 sq. ft.
Boiler pressure	190 lbs.	200 lbs.	190 lbs.

The Northwestern type gave excellent results, although the trains were too light to show its best work. Its record was nearly 8 per cent. better than that of the regular 8-wheel engine for this service. It should be said that the 10-wheel engine, No. 2,012, was also at a disadvantage because of the very light trains. Mr. Waitt expressed confidence in the wide firebox and believed that this engine was a step in advance, indicating the lines which future fast passenger engines should take. He was particularly well pleased with the comparative smokelessness of the Northwestern engine. Twelve cars weighing, with the engine, 710 tons were hauled from New York to Albany by this engine, August 31, on the Adirondack train, No. 55, and between Poughkeepsie and Albany, 70 miles, the time of the "Empire State" was made, which on the next day engine No. 2,012, the 10-wheel type, failed to do.

Mr. Quayle is an advocate of large heating surfaces and great boiler power. Herein seem to be the features of this engine, and the grate contributes a large part of the boiler capacity. The difference between this and the Atlantic type is in the outside arrangement of the boxes of the trailers. This was done to spread the points of support at the firebox, reduce the overhang of the firebox at the sides and support the mud ring at its extreme width. It gives a wider base to the engine at the back end and should produce excellent results in smooth riding. The inside journal bearings for the trailing axle have been considered by many as a serious objection to the wheel arrangement of the Atlantic type, and we have heard complaints of hard riding, tending to confirm this opinion, but whether the difficulty cannot be overcome in an easy way is an interesting question. This is rather important, because of the complication of parts when the boxes are placed outside. A certain advantage, however, of the Northwestern arrange-

Relative Performances of "Northwestern Type" and New York Central Passenger Engines. Compared on New York Central Trains Nos. 18 and 51 (Empire State Express) between New York and Albany. Records of Five Consecutive Days.

Engines.	N. Y. C. No. 870.	N. W. No. 1017.	N. Y. C. No. 2012.	Difference between No. 870 and (In actual results.) No. 1017.	No. 2012.	(In percentage.) No. 1017.	No. 2012.
Totals for five days.							
Lbs. coal for trains, and used in round house	89,830	80,950	94,390	8,880	4,560	.....	.....
Number of cars hauled 143 miles	66	64	69	2	3	3 less.	4.5 more.
Ton miles	430,144	420,277	439,296	9,867	9,152	2.3	2.1
Average, five days.							
Lbs. coal per car hauled 143 miles	1,361	1,265	1 368	96	7	.....	.....
Lbs. coal per round trip	17,466	16,190	18.878	1,776	912	9.8	5.1
Lbs. coal per car mile	9 52	8 84	9 56	0.68	0.04	7 1	0.4
Lbs. coal per ton mile	0 2088	0.1925	0.2142	0.0163	0.0054	7.8	2.6


1101/2" Ring
Cen. of Main Driver To Face of Cylinder
Cen. of Main Driver To Cen. of Cylinder
20" x 26"
Cen. of Cylinder to Cen. of Boiler
36" Cylinder Cen'rs
114 Bumper
21-Link Cen's
86" Cen's

"Northwestern Type" Passenger Locomotive.

Fig. 1.—Side Elevation and Sections.

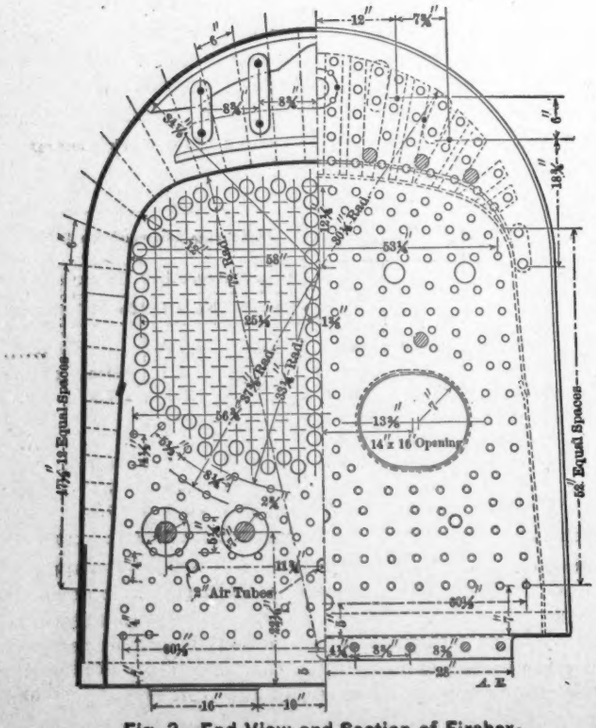


Fig. 3.—End View and Section of Firebox.

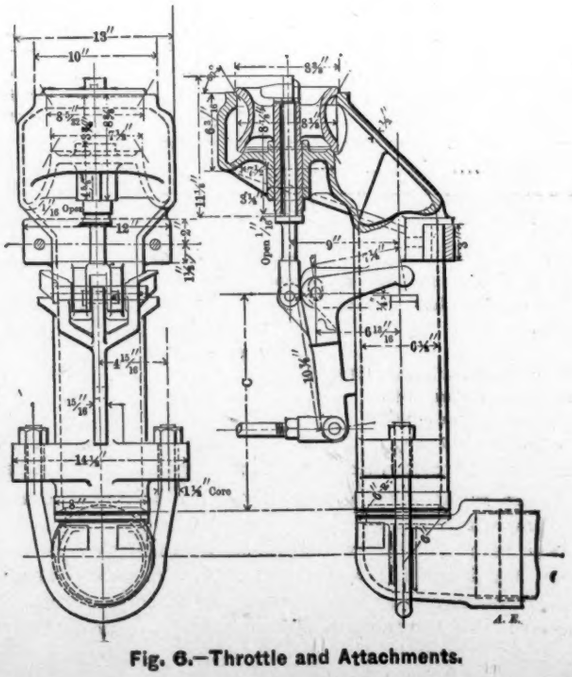


Fig. 6.—Throttle and Attachments.

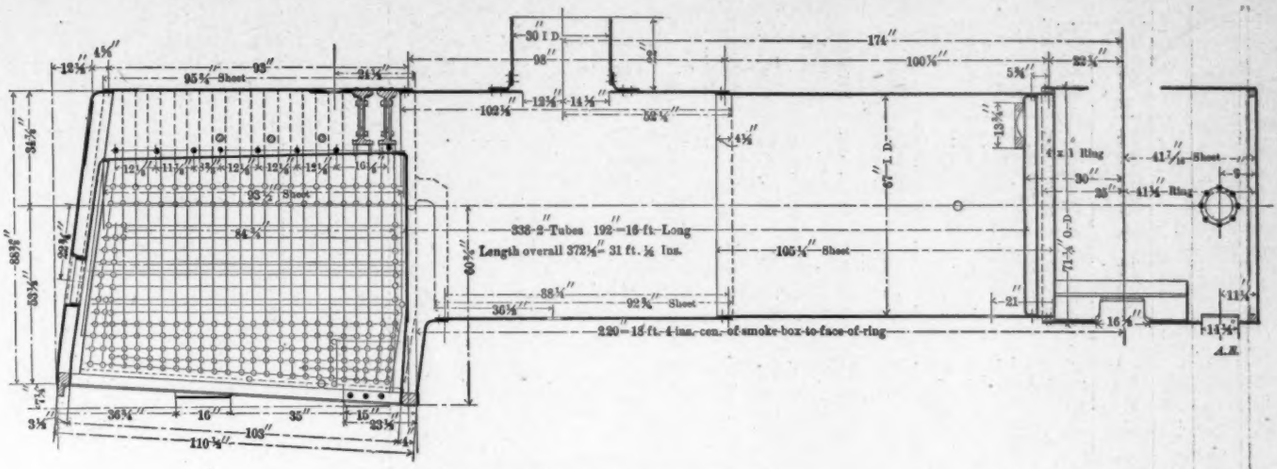


Fig. 2.—Longitudinal Section of Boiler.

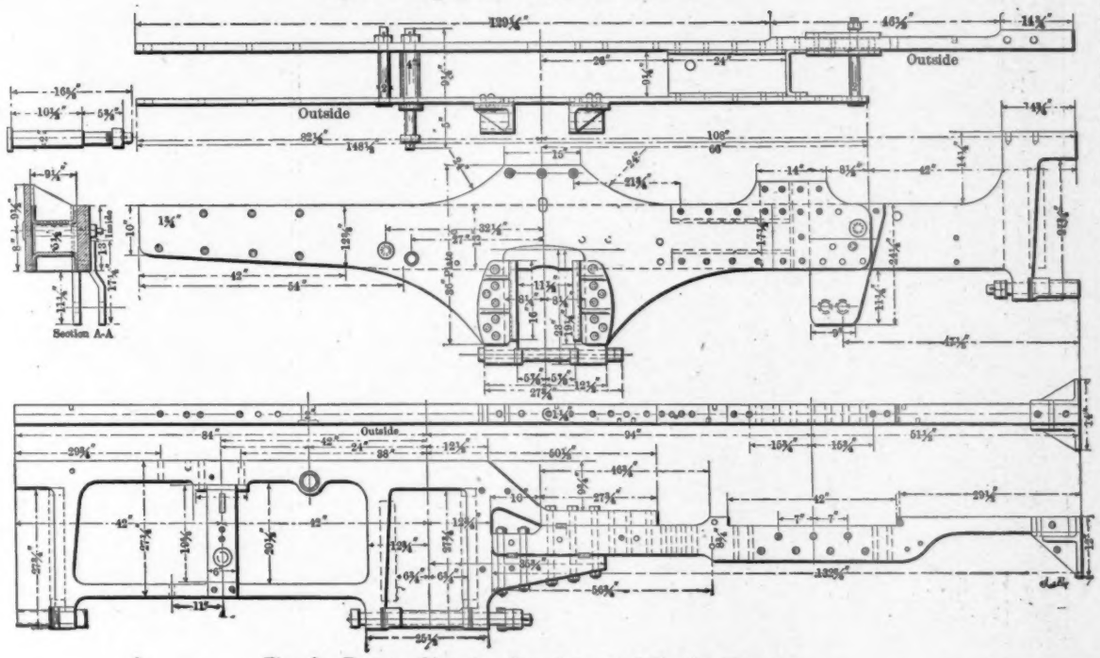


Fig. 4.—Frames Showing Supplemental Trailer Frames.

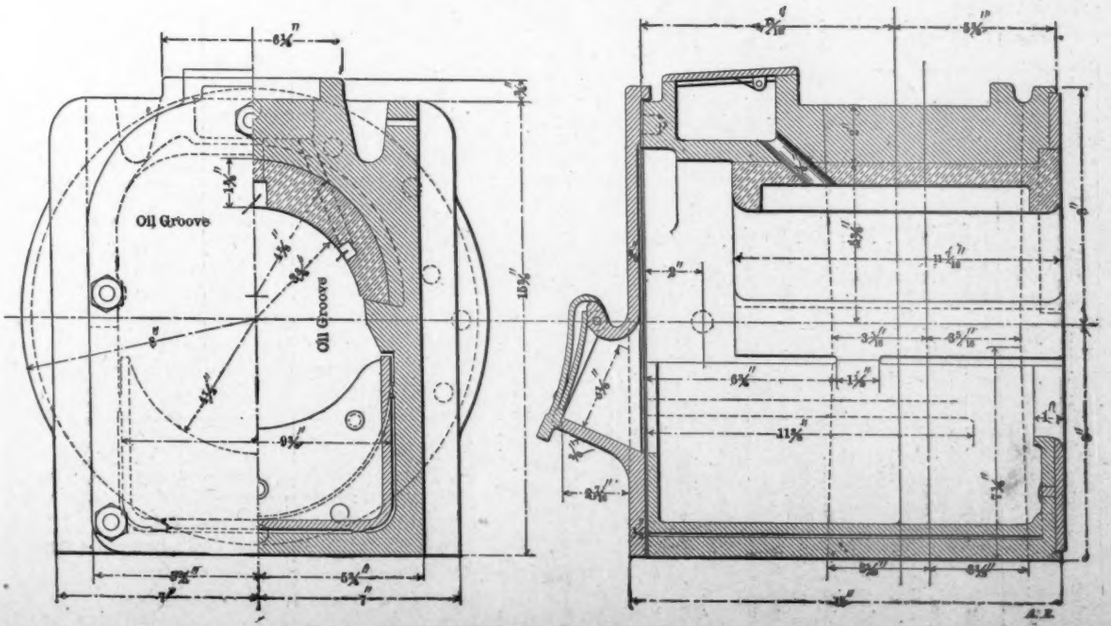


Fig. 5.—Journal Boxes for Trailing Axle.

THE "NORTHWESTERN" TYPE COMPARED WITH VARIOUS ATLANTIC TYPE LOCOMOTIVES.

Number	1015	1591	838	601 5	209	.....	.....	512	.....	820	.....	.....	.....
Road	C. & N. W. "N. W." Type.	C. B. & Q. Atlantic.	C. M. & St. P. Atlantic.	Wabash. Atlantic.	Can. Pac. Atlantic.	Lehigh Val. Atlantic.	Atlantic City. Atlantic.	Erie Atlantic.	C. R. R. of N. J. Atlantic.	P. R. R Atlantic.	Atlantic French State.	Atlantic Westphalian Rys.	Great Northern of England.
Weight { On drivers	90,000 lbs.	85,850 lbs.	71,600 lbs.	86 000 lbs.	80,000 lbs.	81,800 lbs.	78 600 lbs.	84.290 lbs	80,000 lbs.	101,450 lbs.	71,905 lbs.	66,140 lbs.	69,440 lbs.
On truck	35,000 lbs.	40,200 lbs.	40,000 lbs.	.....	.....	29, 50 lbs.	37,000 lbs.	36,545 lbs.	.....	38,125 lbs.	32,700 lbs.	34,170 lbs.	33,600 lbs.
Total	162,000 lbs.	159,050 lbs.	140,700 lbs.	159,585 lbs.	159,000 lbs.	140,950 lbs.	113,000 lbs.	151,000 lbs	141,000 lbs.	173,450 lbs.	139,055 lbs.	128,970 lbs.	129,920 lbs.
Wheel base { Driving	7 ft. 0 in.	7 ft. 6 in.	6 ft 9 in.	7 ft. 0 in.	7 ft. 3 in.	6 ft. 7 in.	7 ft. 3 in.	6 ft. 7 in	7 ft. 3 in.	7 ft. 5 in.	7 ft. 3 in.	6 ft 10 in.	6 ft 10 in.
Total	23 ft. 9 in.	27 ft. 1 in.	25 ft. 6 in.	24 ft. 5¾ in.	25 ft. 11½ in.	24 ft. 0 in	26 ft. 7 in.	24 ft. 9 in.	26 ft. 5 in.	26 ft 6½ in.	26 ft. 5 in.	28 ft. 6¼ in.	26 ft. 4 in.
Cyl. { Dia. x stroke	20 in. x 26 in.	13½ & 23x26 in.	13 & 22 x 25 in.	19 in. x 26 in.	13½&23x26 in	19 in. x 26 in.	13 & 22x26 in.	13 & 22x19 in.	13 & 22x26 in.	20½ x 26 in.	17¼ x 26 in.	19¼ x 22⅝ in.	19 in. x 24 in.
Spread	86 in.	87 in.	87 in.	.....	.....	83 in.	.....	.....	.....	85½ in.	.....	22 7/16 in.	95 in.
Driving wheels { Diam	80 in.	84¼ in.	78 in.	73 in.	84 in.	76 in.	84¼ in.	76 in.	84¼ in.	80 in.	84¼ in.	78 5/16 in.	81 in.
Cent. diam	74 in.	78 in.	72 in.	.....	.....	70 in	.....	.....	.....	.....	78 in.	.....	.....
Material	Steel.	Steel.	Steel.	Steel.	Steel.	Steel.	Steel.	Steel	Steel.	Steel.	Steel.	.....	.....
Driving journals	9 in. x 12 in.	8 in. x 12 in.	8 in. x 12 in.	8 in. x 9 in.	8½ x 12 in.	8½ x 11 in.	8½ x 12 in.	.....	8½ x 12 in.	{ Main 9½x13 in. }	8 in. x 10 in.	8½ x 8.86 in.	.....
Eng. Truck { Wheels	36 in.	36 in.	36 in.	33 in.	36 in.	36 in.	36 in.	.....	36 in	36 in	36 in.	37½ in.	43½ in.
Journals	6 in. x 10 in	5½ in. x 10 in.	5½ in. x 10 in	5 in. x 9 in. 4 in.	6 in. x 10 in.	5½ x 9 in. 4 in.	5½ x 12 in.	.....	5½ x 12 in.	5½ x 10 in.	6 in. x 10 in.	6 7/16 x	.....
Frames, width	4 in.	5 in.	.....	.....	.....	Wide firebox.	.....	.....	.....	.....	.....	.....	.....
Boiler, type	Straight.	Straight.	Straight.	{ Ext. Wag. Top.	Belpaire.	61 in.	Wide firebox. 58¾ in.	Wide firebox. 61 in.	Wide firebox. 58¾ in.	{ Modified Belpaire } 67 in.	Straight. 58 in.	Wag. top. 57 in.	Straight. 56 in.
" dia., O. D, 1st ring	68 in.	62 in.	60 in.	62¾ in.	62 in.	180 in.	200 in.	200 in.	.....	185 in.	213 in.	191 in.	175 in.
" pressure	200 in.	210 in.	200 in.	210 in.	210 in.	61 in.	114 x 96 in.	96 x 96 in.	114 x 96 in.	104 x 96 in.	120 x 42 in.	60 x 72⅝ in.	.....
Firebox	102⅛ x 65¼ in.	121 x 40⅝ in.	103 in. x 42⅛ in.	101⅛x 42½ in.	110 x 42⅝ in.	114⅝ x 80⅝in	278 1¾ in.	271—2 in.	278 - 1¾	353—1¾ in.	246—2 in.	259—1⅛ in.	191—2 in.
Tubes, No. of and diam.	338—2 in.	248—2¼ in.	264 - 2 in.	300—2 in.	284—2 in.	265—2 in.	13 ft. 0 in.	15 ft. 0 in.	13 ft. 0 in.	13 ft. 0 in.	15 ft. 1 in.	15 ft. 5 in.	13 ft. 0 in.
" Length	16 ft. 0 in.	16 ft. 0 in.	15 ft. 0 in.	14 ft. 3 in.	15 ft. 0 in.	15 ft. 1 in.	.....	.....	.....	.....	.....	.....	7 88
Cyl. volume	9.46	.....	.....	8.52	.....	8.52	1,614.9 sq. ft.	2,116.6 sq. ft	1,614.9 sq. ft.	9.93	7.03	7.54	1,302 sq. ft.
Heating surface. { Tubes	2816.91 sq. ft.	2,320 sq. ft.	2,073.5 sq. ft.	2,223 sq. ft.	2,231 sq. ft.	2,081.2 sq. ft.	Com. cham. 53.8	.....	.....	2,204.4 sq. ft.	1,925.4 sq. ft.	.....	.....
Arch tubes	28.27	.....	.....	.....	.....	.....	136.4	168.8	190.2	218	170.4	.....	140
Firebox	170.70	180	171	200	170	148.9	1,808.1 sq. ft.	2,285.4 sq. ft.	1,805.1 sq. ft.	2,320.4 sq. ft.	2,095.8 sq. ft.	1,848.3 sq. ft.	1,442 sq. ft.
Total	3015.88 sq. ft.	2,500 sq. ft.	2,244.5 sq. ft.	2,423 sq. ft.	2,401 sq. ft.	2,230.2 sq. ft.	76 sq ft.	64 sq. ft.	76 sq. ft.	69.33 sq. ft.	35 sq. ft.	30.25 sq. ft.	26.75 sq. ft.
Grate surface	46.27 sq. ft.	35 sq. ft.	30 sq. ft	29.92 sq. ft.	32.25 sq. ft.	63.97 sq. ft.	14,352	15 911	.....	23,430	16,066	17,195	15,915
Trac. power	22,100	16,827	15.502	22,951	16,978	18,900	188.8	248.61	.....	338.4	459.03	568.43	594.95
Trac. power ÷ G. S	477.63	480.7	516.7	767.08	526.45	295.4	.....	.....	.....	7	4.97	4.01	3.44
G. S. ÷ cyl. vol	4.89	.....	.....	3.5	.....	7.5	.....	.....	.....	233.67	298.13	245.13	183
H. S. ÷ cyl. vol	318 8	.....	.....	284.39	.....	261.76	.....	.....	23.75	33.4	59.88	61.10	53.9
H. S. ÷ G. S	65.18	70	75	81	74	35	.....	.....	.....	109	.....	97 7/16	95
Center of boiler fr. rail	109½ in.	108 in.	104½ in.	103 in.	106.5 in.	106¼ in.	105¼ in.	.....	.....	56 in.	54¼ in.	37.4 in.	43½ in.
Trailing wheels	48 in.	54¼ in.	54 in.	57 in. (Est.)	58 in.	.....	54¼ in.	.....	54¼ in.	33.755 lbs.	34,450 lbs.	28.660 lbs.	26,880 lbs.
" journals	7½ in. x 12 in.	8½ in. x 12 in.	7 in. x 12 in.	8 in. x 9 in.	8½ x 12 in.	7 in. x 12 in.	7 in. x 12 in.	30,175 lbs.	7 in. x 12 in.	7 x 11¾ in.	8 in. x 10 in.	5½ x	.....
" weight	37,000 lbs.	33,000 lbs.	29,000 lbs.	.....	.....	30,050 lbs.	.....	.....	.....	101 in.	.....	104¾ in.	99 in.
Center truck to 1st driving axle	94 in.	104 in.	100 in.	91¼ in.	98½ in.	95 in.	104 in.	.....	.....	89 in.	87 in.	80.71 in.	82 in.
Length of side rod	84 in.	90 in.	81 in.	84 in.	87 in.	79 in.	87 in.	.....	.....	89 in.	87 in.	123⅝ in.	96 in.
Cent'r rear drivers to cent'r trailers	108 in.	90 in.	84 in.	84 in.	87 in.	77 in.	87 in.	.....	.....	89 in.	87 in.	.....	6-W.
Tender, frame	Channel, 8-W.	Channel, 6-W.	Channel, 8-W.	Chan'l, 8-W.	Chan'l, 8-W.	Chan'l, 8-W.	Chan'l, 8-W.	Chan'l,8-W.	.....	Chan'l, 6-W.	Chan'l, 8-W.	.....	49½ in.
" wheel diam	36 in.	42¼ in.	33 in.	36 in.	40 in.	36 in.	36 in.	.....	36 in.	42 in.	36 in.	.....	.....
" journals	5 in. x 9 in.	6¼ in. x 10 in.	4¼ in. x 8 in.	4¼in. x 8 in.	5 in. x 9 in.	.....	5 in. x 8 in.	.....	5 in. x 8 in.	5 in. x 9 in.	4¼ in. x 8 in.	.....	.....
" capacity, galls	5,200	5,000	4,500	4,500	5,400	4,000	3 500	6,000	3,500	5,000	3,600	3,527	3,650

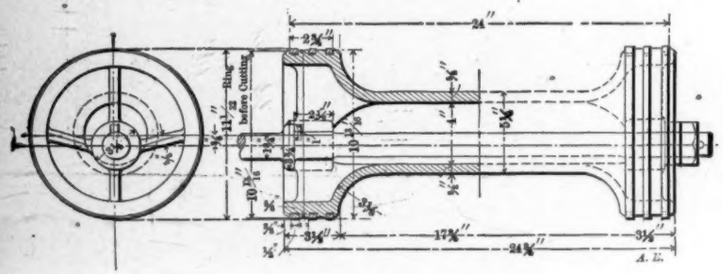
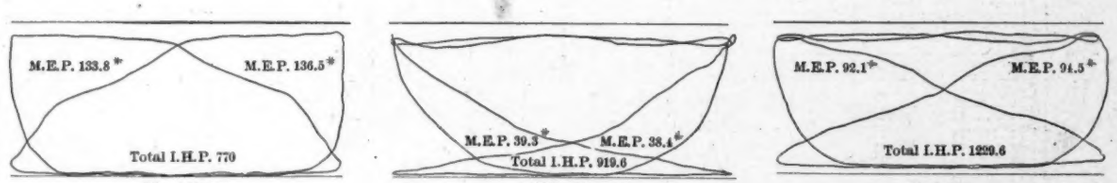


Fig. 7.—Piston Valve.



No. 170 — 70 Rev. Per Min. — 193 Steam Pressure — 16.7 Miles Per Hour — ⅝ Throttle

No. 83 — 291 Rev. Per Min. — 197 Steam Pressure — 69.3 Miles Per Hour — Throttle Full

No. 174 — 162 Rev. Per Min. — 192 Steam Pressure — 38.6 Miles Per Hour — Throttle Full

A. E.

Fig. 8.—Indicator Cards from "Northwestern Type" Locomotive.

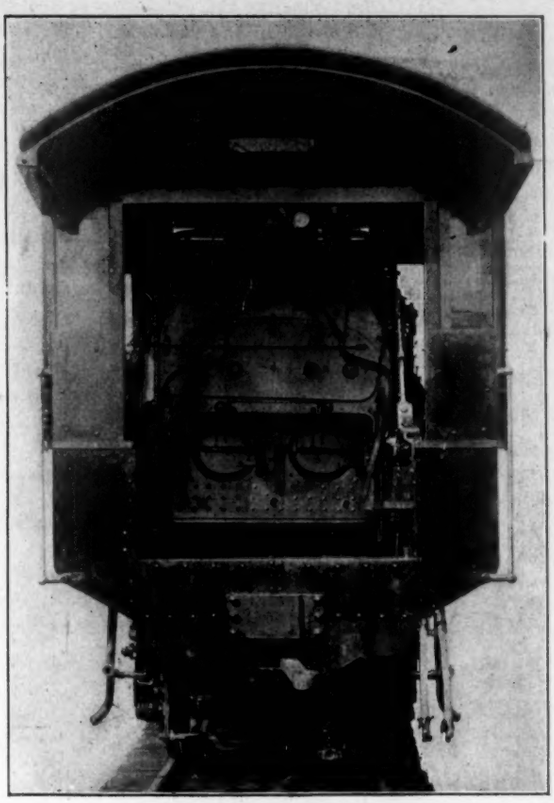


Fig. 9.—Rear View of Cab.

ment is a good space for the ashpan. The supplemental frames, shown in Fig. 3, give a very satisfactory support to the mud ring, and they probably weigh less than the large steel castings used on the C., B. & Q. "Prairie Type" (American Engineer, April, 1900, page, 103).

The side elevation, Fig. 1, illustrates the general features. The rear elevation and section and the photograph, Fig. 9, show that in spite of the width of the firebox, 5 ft. 5¼ in., there is ample room in the cab. The two fire doors are 14 by 16 in. in size, and the deck is wide enough to render the firing easy. The equalizing system is, for the driving wheels, as usual, and in front of the trailers a cross equalizer connects the two sides and takes care of the offset to the trailer springs. The side view also shows the method of supporting the firebox and the construction of the valve motion connections to get past the front driving axle. The motion is not changed at the rocker shaft, because both of the rocker arms extend downward and the valve has internal admission. The driving wheels are 80 in. in diameter in order to give high speed, and the cylinders are 20 by 26 in. in order to start quickly. The next step was to provide boiler power to give endurance.

The boiler is seen in Fig. 2, and the firebox in Fig. 3. It needs no comment, except to direct attention to the long tubes, 16 ft., the sloping back head and straight sides of the firebox and the thickness of the sheets, which are as follows: Crown sheet, ⅜ in.; tube sheet, ½ in.; side and back sheets, ⅜ in. The mud ring has lugs forged upon its lower face to take the weight and receive the fastenings. The outside firebox sheet is in a single piece, while the inside sheet is in three parts for ease in renewing the side sheets.

There is nothing unusual about the main frames, but the outside supplemental frames shown in Fig. 4 are specially interesting. They receive the weight of the boiler at the back end and over the trailer boxes. These boxes are carried in heavy pedestals of cast steel bolted to the outside faces of the supplemental frames. The method of securing the short and long frames together at the rear is shown in the upper view of Fig. 4. The trailer boxes are shown in Fig. 5. The whole front is in a single piece and removable after taking out the screws. Owing to the possibility of heating, due to the proximity to the firebox the engines were arranged to lubricate these bearings in several different ways in order to determine the best method. One had the oil groove in the top of the brass, another had grooves in the sides of the bearing only, and another had the oil groove at the top of the bearing and also four plumbago plugs fitted to cavities at the sides. The holes for the plumbago are ⅞ in. in diameter, and ⅜ in. deep. The hub bearings of these boxes are faced with babbitt.

The throttle design is that of Mr. A. S. Vogt, Mechanical Engineer of the Pennsylvania. By comparing Fig. 6 with the designs for the Pennsylvania Class E-1 engines on page 170 of our June number the resemblance is apparent. The throttle not only has a large leverage for its initial opening and a faster movement for its remaining movement, but careful attention has been given to the directness of the steam passage into and through the throttle pipe. It will be noticed that this valve opens only at the top of the pipe, and the valve being hollow there is no sacrifice of area while the dryest steam only is taken. All who have seen this throttle speak in high praise of it.

The piston valves, Fig. 7, are 11 in. in diameter. They have internal admission and the packing is in the form of three narrow plain snap rings, which is considered by these builders to be the most satisfactory packing for piston valves. The edges of the valves are beveled off outside the rings in order to make the rings give a clear cut-off edge. This valve is hollow, light and very simple.

Some interesting indicator cards taken from one of these engines seem worthy of reproduction. We have selected three, which show the effects of good steam and exhaust passages, high horse-power and low back pressure.

Cards Nos. 170 and 174 were taken on train No. 15 between Albany and Utica on the line of the New York Central, and No. 83 was taken while the engine was pulling the Empire State Express at 69 miles an hour.

For convenience in comparing this engine with others having similar wheel arrangement the table on page 304 is reproduced by courtesy of Mr. L. R. Pomeroy, of the Schenectady Locomotive Works. It is at once apparent that this is a wonderfully powerful engine when compared with others in this list. It does not, however, represent the limit of capacity for four coupled wheels, and one of its strongest advantages is that the boiler may yet be made more powerful by using longer tubes and wider grates. It is but a step from this design to one like Mr. Delano's "Prairie Type," but with three pairs of 80-in. drivers and 20-ft. tubes. Such an engine will soon be built by another road and it will be worth watching.

Mr. John A. Secor, Engineer-in-Chief of the General Power Company, New York, read a valuable and timely paper before the New York Railroad Club, at its September meeting, upon the subject of internal-combustion engines. After reviewing the history of this type of engine, and showing its advantages over steam in economy, the question of fuel was considered, and the very great advantages of oil over gas and the lighter petroleum products were clearly brought out. The speaker outlined the qualifications of a successful internal-combustion engine and led up to his solution of the problems in the engines of his design. These use oil, which is available everywhere, they are of the vertical type and most simple in construction. They do not require a "carburetter" and they appear to be admirably adapted to railroad work in shops and elsewhere.

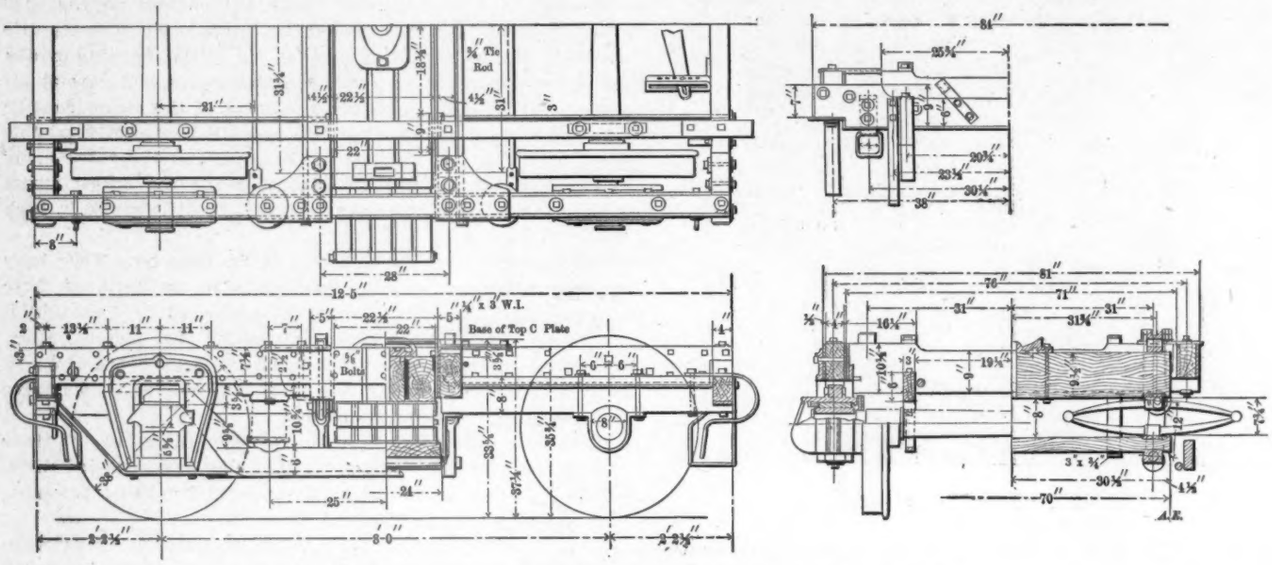
The Marconi system of wireless telegraphy has been definitely adopted for the British navy, and, according to "The Engineer," 25 sets have been purchased. Marconi gets $500 royalty per year on each set. There seems to be no question among British naval men that this is the best wireless system.

FOUR-WHEEL PASSENGER CAR TRUCK.

With 5 by 9-inch Journals.

Illinois Central Railroad.

This truck at the first glance appears to be merely a design for the use of 5 by 9-in. journals in passenger equipment. It is not for novelty in design that it is presented, but because it represents an effort at improvement in passenger car practice which has now fairly begun and seems likely to lead to rather radical changes.



Four-Wheel Truck, with 5 by 9-in. Journals. For Heavy Passenger Cars.
Illinois Central Railroad.

This truck, which is illustrated through the courtesy of Mr. Wm. Renshaw, Superintendent of Machinery of the Illinois Central, and Mr. W. H. V. Rosing, his assistant, was designed to enable that road to use four-wheel trucks in place of present ones with six wheels, under buffet and smoking cars, in the hope that they will be found sufficiently satisfactory for use under other cars now having six-wheel trucks. The object is to save weight and expense of construction and repairs. If the riding qualities of the six-wheel truck can be secured with a saving of four wheels, two axles and the accompanying parts for every car, the idea will at once be accepted as a marked improvement in a direction in which there has been little change for a number of years. The six-wheel trucks for heavy passenger cars are very strong and in many ways satisfactory. They have, however, grown in weight and in number of parts entirely out of proportion to the loads they carry, until the present truck of the Pullman type is a complex and complicated combination of wood, iron and steel, the number of parts in which must be seen as spread out for assembling in order to be appreciated. Wooden members originally sufficed for the frames. Steel reinforcements were added as the weights of cars increased, and very little thought has been given to the question of cost and weight as long as good service was given. It is hoped that this new design will be successful enough to bring to the subject of trucks the attention it merits.

The earlier six-wheel trucks had 3¾ by 7-in. journals. These have given place in many cases to 4¼ by 8-in. journals, and to get sufficient strength for carrying the weight on four wheels Mr. Renshaw uses the 5 by 9-in. M. C. B. journal and axle. The equalizers are 6 in. deep and the frames are made stronger. No other novelties are seen in the drawing.

About 3,000 lbs. per truck are believed to be saved in the total weight, and at present prices the difference in cost will probably be about $500 per car in the first cost. This is accompanied by an important saving in maintenance of two steel wheels, two axles, pedestals and bearings, and a large number of accessory parts in each truck, to say nothing of the frames themselves. In a train of 15 Pullman cars, provided the four-wheel truck can be used, the saving in weight would be about 93,000 lbs., or more than the weight of one of the heavy cars.

Other roads, following the example of the Illinois Central, have already considered the subject, and several entirely new passenger truck designs may be expected. It is important to reduce the weight of passenger trains in every practicable way. In order to insure complete success in this direction, however, improvements in the spring arrangements will be needed, or the four-wheel type will fall short of the six-wheel in smooth riding.

Since this description was written we have received from Mr. A. M. Kittredge, Vice-President of the Barney & Smith Company, builders of the new trucks for the Illinois Central, the following information. The new four-wheel trucks, with 5 by 9-in. journals, weigh 29,900 lbs. per set, and the cost to-day would be about $1,250 for two trucks. The standard Illinois Central six-wheel trucks weigh about 36,100 lbs. per set, and they would cost to-day about $1,825 per set. This places the saving in weight per car at 6,200 lbs. and in cost at $575, to say nothing of the saving in maintenance.

CLOSING OF THE ROGERS LOCOMOTIVE WORKS.

Upon the death of Mr. Robert S. Hughes, President of the Rogers Locomotive Works, Mr. Jacob Rogers, the chief owner, who has not been active in the management for ten years, decided that he did not wish to continue the business on account of his age and the necessity for new equipment to place the plant in a favorable position for competing with the other builders. The plant at Paterson, which has been in operation since 1852, was never favorably situated, having no railroad connection, and the continuance of the business probably appears to Mr. Rogers a serious undertaking. Efforts have been made to buy and continue the works, but they have, we believe, been unsuccessful. Many of our readers will learn with regret that the works will close when the present orders are completed, probably in December.

LOCOMOTIVE DESIGN.*

By F. J. Cole, Mechanical Engineer, Rogers Locomotive Works.

Traction Force and Adhesion.

Unlike other forms of steam engines or motors of various kinds, the power of a locomotive is not usually estimated as of so many horse-power, either for comparison or for determining the weight of trains which can be hauled, but rather as having a certain amount of tractive force in pounds. In order to properly proportion the boiler, so that ample grate area, heating surface, etc., is provided to generate steam in sufficient quantity, it is often desirable to know the amount of horse-power which a locomotive can develop at different speeds, but the tractive force of an engine is the usual measure of its power.

By the tractive force is meant the push or pull of the cylinders on the crankpin, reduced to the point of contact of the tire and the rail. By making suitable deduction for the power required to overcome the internal friction of the engine, and also the power required to move the engine and tender, the tractive force will equal the drawbar pull at the rear of the tender. The theoretical tractive force is expressed by the well-known formula:

$$T = \frac{d^2 \times L \times P}{W}$$

where T = tractive force in pounds
d = diameter of cylinder in inches
L = stroke in inches
W = diameter of driving wheels.
P = Mean effective pressure in pounds.

The power of the two cylinders at the point of contact between the wheels and rail is given in the above formula, the form in which it appears being an abbreviation or cancellation of the entire formula

$$T = \frac{2\ (d^2 .7854) \times L\ 2}{W\ 3.1416} = \frac{d^2 \times L}{W}$$

Tables No. 1 and No. 2 give the tractive force per pound of mean effective pressure on the pistons for various sizes of cylinders and wheels. In calculating the maximum tractive force it is customary to assume that the mean effective pressure at slow speeds—say under 200 ft. piston speed per minute—is equal to about 85 per cent. of the boiler pressure. For example, a locomotive having 20 x 28-in. cylinders with drivers of 62-in. diameter and 200 lbs. boiler pressure, would have a tractive force of $180.6 \times .85 \times 200 = 30{,}700$ lbs. While the M. E. P. is usually taken at 85 per cent. of the boiler pressure, this is only an approximation, as the range is between 83 and 88 per cent. Table No. 3 shows the various percentages of pressures from 140 to 250.

Probably the simplest and clearest way to consider the power of a locomotive is to use the same unit of work, "the foot-pound," which is the universal measure of work or energy among English-speaking people.

An impression seems to exist that under certain conditions, a locomotive is capable of pulling up a grade a load greater than can be accounted for by the usual rules governing the tractive power, and that the generally accepted formula does not always account for all the power which an engine can exert. Accounts of phenomenal train loads have occasionally been published by means of which the writers have endeavored to prove that the energy exerted was greater than could be accounted for by ordinary rules, even if the mean effective pressure was equal to that in the boiler. If the work performed by the locomotive is estimated like other kinds of work in foot-pounds, it may, perhaps, be more clearly understood.

The thrust of both the pistons multiplied by four times the stroke in feet is the number of foot-pounds of work done during one revolution of the driving wheels. This divided by the circumference of the wheel in feet, will equal the number of foot-pounds of work the engine is capable of exerting. For instance, if the cylinders are 20 in. in diameter and 28 in. stroke, the drivers 62 in. in diameter, average steam pressure 170 lbs. on the pistons during the entire stroke:

$$F = \frac{2 \times 20^2 .7854 \times 2.33 \times 2 \times 170}{16.23} = 30{,}700 \text{ lbs.}$$

or exactly the same result found by the usual formula.

The tractive force of a locomotive may be briefly described as the force exerted to propel it and to haul the train to which it is coupled. To find the proper diameter of cylinders when tractive force, stroke and diameter of driving wheel is given:

$$D = \sqrt{\frac{T\ W}{1}}$$

when T = the tractive force per pound of M. E. P. Example: Required the diameter of cylinder for a tractive force of 129 lbs., when the diameter of the driving wheel is 72 ins. and the length of stroke is 26 ins. Then:

$$D \sqrt{\frac{T\ W}{2}} = \sqrt{\frac{139 \times 72}{26}} = 18.9$$

To find the diameter of the driving wheels,

$$W = \frac{D^2 L}{T}$$

To find the length of the stroke,

$$L = \frac{TW}{D^2}$$

To find the tractive force,

$$T = \frac{D^2 L}{W}$$

If the tractive force exceeds the adhesion the drivers will slip. Speaking in a general way, the weight on the driving wheels should be from 4 to 4½ times the maximum average tractive force, when the M. E. P. is taken at 85 per cent. of the boiler pressure.

In the proceedings of the Master Mechanics' Association for 1887 the committee appointed to report on the proper proportion of locomotive cylinders and driving wheels recommend the following ratios of tractive force to weight on drivers:

Passenger engines, 4 to 1.
Freight engines, 4.25 to 1.
Switching engines, 4.50 to 1.

Diameter of driving wheels to be taken with tires half worn out.

Since this report was made pneumatic sanding devices have come into very general use, by means of which small quantities of sand may be blown under the wheels for comparatively long distances without exhausting the supply, as formerly was done when hand-operated sandboxes were used exclusively. Taking this into consideration, together with the fact that fractional parts of an inch are introduced into the wheel diameters by assuming the tires to be half worn out, it is more convenient for comparison in calculating the tractive force to consider the wheels to be the full diameter and not half worn out. On this basis, even with the most approved form of sanding apparatus, it is not considered good practice to make the total weight on the drivers less than four times the tractive force when the M. E. P. is assumed to be 85 per cent. of the boiler pressure. For very heavy engines built for exceptional service, good results can often be obtained with a ratio of 4 to 1 or a co-efficient of adhesion of 0.25. For general freight or switching service the ratio should not be less than 4.2 or a co-efficient of 0.238.

The co-efficient of adhesion between the revolving steel tires and steel rails, which may be described as the resistance to

*For previous article see page 176.

TABLE NO. 1.—TRACTIVE POWER PER POUND OF MEAN EFFECTIVE PRESSURE.

Cylinders. Dia. x stroke	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
8 x 12	29.5	28.4	27.4	26.5	25.6	24.8	24.0	23.3	22.6	21.8	21.3	20.8	20.2	19.7	19.2	18.7	18.3																					
8 x 14	34.4	33.2	32.0	31.0	29.9	28.9	28.0	27.1	26.3	25.6	24.9	24.2	23.6	23.0	22.4	21.8	21.3	20.8																				
9 x 12	37.4	36.0	34.7	33.5	32.4	31.4	30.4	29.5	28.6	27.8	27.0	26.3	25.6	24.9	24.3	23.7	23.1	22.6	22.1																			
9 x 14	43.6	42.0	40.3	39.1	37.8	36.6	35.4	34.4	33.4	32.4	31.5	30.6	29.8	29.1	28.3	27.7	27.0	26.4	25.8	25.2																		
9 x 16	49.8	48.0	46.3	44.7	43.2	41.8	40.5	39.3	38.1	37.0	36.0	35.0	34.1	33.2	32.4	31.6	30.9	30.1	29.4	28.8	28.2																	
10 x 14	53.8	51.8	50.0	48.3	46.7	45.2	43.7	42.4	41.2	40.0	38.9	37.8	36.8	35.9	35.0	34.1	33.3	32.6	31.8	31.1	30.4	29.8																
10 x 16	61.5	59.2	57.1	55.2	53.3	51.6	50.0	48.5	47.1	45.7	44.4	43.2	42.1	41.0	40.0	39.0	38.1	37.2	36.4	35.6	34.8	34.0	33.3															
10 x 18	69.2	66.6	64.3	62.1	60.0	58.1	56.2	54.5	52.9	51.4	50.0	48.6	47.4	46.1	45.0	43.9	42.9	41.9	40.9	40.0	39.1	38.3	37.5	36.7														
11 x 14	65.1	62.7	60.5	58.4	56.5	54.6	52.9	51.3	49.8	48.4	47.0	45.8	44.6	43.4	42.3	41.3	40.3	39.4	38.5	37.6	36.8	36.0	35.3	34.6	33.9													
11 x 16		71.7	69.1	66.8	64.5	62.5	60.5	58.7	56.9	55.3	53.8	52.3	50.9	49.6	48.4	47.2	46.1	45.0	44.0	43.0	42.1	41.2	40.3	39.5	38.7	38.0												
11 x 18			77.8	75.1	72.6	70.3	68.1	66.0	64.1	62.2	60.5	58.9	57.3	55.8	54.4	53.1	51.9	50.6	49.5	48.4	47.3	46.3	45.4	44.4	43.6	42.7	41.9											
12 x 16				79.5	76.8	74.3	72.0	69.8	67.8	65.8	64.0	62.3	60.6	59.1	57.6	56.2	54.9	53.6	52.4	51.2	50.0	49.0	48.0	47.0	46.1	45.1	44.3	43.5										
12 x 18					86.4	83.6	81.0	78.5	76.2	74.0	72.0	70.0	68.2	66.5	64.8	63.2	61.7	60.3	58.9	57.6	56.3	55.1	54.0	52.9	51.8	50.8	49.8	48.9	48.0									
12 x 20						92.9	90.0	87.3	84.7	82.3	80.0	77.8	75.8	73.8	72.0	70.2	68.6	67.0	65.4	64.0	62.6	61.3	60.0	58.8	57.6	56.5	55.4	54.3	53.3	52.4								
13 x 16							84.5	81.9	79.5	77.2	75.1	73.1	71.2	69.3	67.6	66.0	64.4	62.9	61.4	60.1	58.8	57.5	56.3	55.2	54.1	53.0	52.0	51.0	50.1	49.2	48.3							
13 x 18								92.2	89.5	86.9	84.5	82.2	80.0	78.0	76.0	74.2	72.4	70.7	69.1	67.6	66.1	64.7	63.4	62.1	60.8	59.6	58.5	57.4	56.3	55.3	54.3	53.3						
13 x 20									99.4	96.6	93.9	91.4	88.9	86.7	84.5	82.4	80.5	78.6	76.8	75.1	73.5	71.9	70.4	69.0	67.6	66.3	65.0	63.8	62.6	61.4	60.3	59.3	58.3					
14 x 18										100.8	98.0	95.4	92.8	90.5	88.2	86.0	84.0	82.1	80.2	78.4	76.7	75.1	73.5	72.0	70.6	69.2	67.8	66.6	65.3	64.1	63.0	61.9	60.8	59.8				
14 x 20											108.9	105.9	103.2	100.5	98.0	95.6	93.3	91.2	89.1	87.1	85.2	83.4	81.7	80.0	78.4	76.9	75.4	74.0	72.6	71.3	70.0	68.8	67.6	66.4	65.3			
14 x 22												116.5	113.5	110.6	107.8	105.2	102.8	100.3	98.0	95.8	93.7	91.8	89.8	88.0	86.2	84.6	82.9	81.4	79.8	78.4	77.0	75.6	74.3	73.1	71.9	70.7		
15 x 18													106.6	103.9	101.2	98.8	96.4	94.2	92.0	90.0	88.0	86.2	84.4	82.6	81.0	79.4	77.9	76.4	75.0	73.6	72.3	71.0	69.8	68.6	67.5	66.4	65.3	
15 x 20														115.4	112.5	109.7	107.1	104.6	102.3	100.0	97.8	95.7	93.7	91.8	90.0	88.2	86.5	84.9	83.3	81.8	80.4	78.9	77.6	76.3	75.0	73.8	72.6	71.4
15 x 22															123.7	120.7	117.9	115.1	112.5	110.0	107.6	105.3	103.1	101.0	99.0	97.1	95.2	93.4	91.7	90.0	88.4	86.8	85.3	83.9	82.5	81.1	79.8	78.6
16 x 18																112.4	109.7	107.2	104.7	102.4	100.2	98.0	96.0	94.0	92.2	90.3	88.6	86.9	85.3	83.8	82.3	80.8	79.4	78.1	76.8	75.5	74.3	73.1
16 x 20																	121.9	119.1	116.4	113.8	111.3	108.9	106.7	104.5	102.4	100.4	98.5	96.6	94.8	93.1	91.4	89.8	88.3	86.8	85.3	83.9	82.6	81.3
16 x 22																		131.0	128.0	125.2	122.4	119.8	117.3	114.9	112.6	110.4	108.3	106.3	104.3	102.4	100.6	98.8	97.1	95.5	93.9	92.3	90.8	89.4
17 x 22																			144.5	141.3	138.2	135.3	132.5	129.8	127.2	124.7	122.3	120.0	117.7	115.6	113.5	111.5	109.6	107.8	106.0	104.2	102.5	100.9

TABLE NO. 2.—TRACTIVE POWER PER POUND OF MEAN EFFECTIVE PRESSURE.

Diameter of Driving Wheels.

Cylinders. Dia. x stroke	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
17 x 24	157.6	154.0	150.8	147.6	144.5	141.5	138.7	136.0	133.4	130.9	128.4	126.1	123.9	121.7	119.6	117.6	115.6	113.7	111.9	110.1
17 x 26	170.8	167.0	163.3	159.9	156.5	153.4	150.3	147.3	144.5	141.8	139.1	136.6	134.2	131.8	129.6	127.3	125.2	123.2	121.2	119.3
17 x 28	183.9	179.8	175.9	172.1	168.6	165.1	161.8	158.7	155.6	152.7	149.8	147.1	144.5	141.9	139.5	137.1	134.9	132.6	130.5	128.4
18 x 24	176.7	172.3	169.0	165.2	162.0	158.7	155.5	152.5	149.5	146.7	144.0	141.4	138.8	136.4	134.1	131.8	129.6	127.5	125.4	123.4
18 x 26	191.4	187.2	183.1	179.2	175.5	171.9	168.5	165.2	162.0	158.9	156.0	153.2	150.4	147.8	145.2	142.8	140.4	138.1	135.9	133.7
18 x 28	206.2	201.6	197.2	193.0	189.0	185.1	181.4	177.9	174.5	171.2	168.0	164.9	162.0	159.2	156.4	153.7	151.2	148.7	146.3	144.0
18 x 30	220.9	216.0	211.3	206.8	202.5	198.4	194.4	190.6	186.9	183.4	180.0	176.7	173.6	170.5	167.6	164.7	162.0	159.3	156.8	154.3
19 x 24	196.9	192.5	188.3	184.2	180.5	176.8	173.3	169.9	166.6	163.5	160.4	157.5	154.7	152.0	149.4	146.8	144.4	142.0	139.7	137.5
19 x 26	213.3	208.6	204.0	199.7	195.5	191.6	187.7	184.0	180.5	177.1	173.8	170.7	167.6	164.7	161.8	159.1	156.4	153.9	151.4	149.0
19 x 28	229.7	224.6	219.7	215.1	210.6	206.3	202.1	198.2	194.4	190.7	187.2	183.7	180.5	177.3	174.3	171.3	168.5	165.7	163.0	160.4
19 x 30	246.1	240.7	235.4	230.4	225.6	221.0	216.6	212.3	208.3	204.3	200.6	196.9	193.4	190.0	186.7	183.5	180.5	177.5	174.7	171.9
19 x 32	262.5	256.7	251.1	245.8	240.7	235.7	231.0	226.5	222.2	217.9	214.0	210.0	206.3	202.7	199.2	195.8	192.6	189.4	186.3	183.6
20 x 24					200.0	195.9	192.0	188.2	184.6	181.1	177.8	174.5	171.4	168.4	165.5	162.7	160.0	157.4	154.8	152.4
20 x 26					216.7	212.3	208.0	203.9	200.0	196.2	192.6	189.1	185.7	182.5	179.3	176.3	173.3	170.5	167.7	165.1
20 x 28									215.4	211.3	207.4	203.6	200.0	196.5	193.1	189.8	186.7	183.6	180.6	177.8
20 x 30											222.2	218.1	214.3	210.5	206.9	203.4	200.0	196.7	193.6	190.5
20 x 32														224.5	220.7	216.9	213.3	209.8	206.4	203.2
21 x 24							211.7	207.5	203.5	199.7	196.0	192.4	189.0	185.7	182.5	179.4	176.4	173.5	170.7	168.0
21 x 26							229.3	224.8	220.5	216.3	212.3	208.5	204.7	201.2	197.7	194.3	191.1	188.0	184.9	182.0
21 x 28									237.5	233.0	228.7	224.5	220.5	216.6	212.9	209.3	205.8	202.4	199.2	196.0
21 x 30											245.0	240.5	236.3	232.1	228.1	224.2	220.5	216.9	213.4	210.0
21 x 32														247.6	243.3	239.1	235.2	231.3	227.6	224.0
21 x 34														263.0	258.5	254.1	249.9	245.8	241.8	238.0
22 x 26							251.7	246.7	242.0	237.4	233.0	228.8	224.7	220.8	217.0	213.3	209.7	206.3	203.0	199.7
22 x 28									260.6	255.7	250.9	246.4	242.0	237.7	233.6	229.7	225.9	222.2	218.6	215.1
22 x 30											268.9	264.0	259.3	254.7	250.3	246.1	242.0	238.0	234.2	230.4
23 x 30											293.9	288.5	283.4	278.4	273.6	268.9	264.5	260.2	256.0	251.9
23 x 32											313.5	307.8	302.3	296.9	291.8	286.9	282.1	277.5	273.0	268.7
23 x 34											333.1	327.0	321.2	315.5	310.1	304.8	299.8	294.8	290.1	285.5
24 x 30											320.0	314.2	308.6	303.1	297.9	292.8	288.0	283.3	278.7	274.3
24 x 32											341.3	335.1	329.1	323.4	317.8	312.4	307.2	302.2	297.3	292.6
24 x 34											362.7	356.1	349.7	343.6	337.7	331.9	326.4	321.0	315.8	310.8
25 x 32											370.4	363.6	357.1	350.9	344.8	338.9	333.3	327.9	322.6	317.4

Cylinders. Dia. x stroke	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
17 x 24	108.4	106.7	105.1	103.5	102.0	100.5	99.1	97.7	96.3												
17 x 26	117.4	115.6	113.8	112.1	110.5	108.9	107.3	105.8	104.4	102.9											
17 x 28	126.4	124.5	122.6	120.8	119.0	117.3	115.6	114.0	112.4	110.8	109.3	107.9									
18 x 24	121.5	119.6	117.8	116.1	114.4	112.7	111.1	109.5	108.0	105.5	105.1	103.7									
18 x 26	131.6	129.6	127.6	125.7	123.9	122.1	120.3	118.6	117.0	115.4	113.8	112.3									
18 x 28	141.7	139.6	137.4	135.4	133.4	131.5	129.6	127.8	126.0	124.3	122.6	121.0									
18 x 30	151.9	149.3	147.3	145.1	142.9	140.9	138.8	136.9	135.0	133.1	131.3	129.6									
19 x 24	135.4	133.3	131.3	129.3	127.4	125.6	123.8	122.0	120.3	118.7	117.1	115.5	114.0	112.5	111.1	109.7	108.3	107.0	105.7	104.4	103.1
19 x 26	146.7	144.4	142.2	140.1	138.0	136.0	134.1	132.2	130.4	128.6	26.8	125.1	123.5	121.9	120.3	118.8	117.3	115.9	114.5	113.1	111.7
19 x 28	157.9	155.5	153.1	150.8	148.6	146.6	144.4	142.4	140.4	139.4	136.6	134.8	133.0	131.3	129.6	127.9	126.3	124.8	123.3	121.8	120.3
19 x 30	169.2	166.6	164.1	161.6	159.3	156.9	54.7	152.5	150.4	148.3	146.3	144.4	142.5	140.4	138.8	137.1	135.4	133.7	132.1	130.5	128.9
19 x 32	180.5	177.7	175.0	172.4	169.9	167.4	165.0	162.7	160.4	158.2	156.1	154.0	152.0	150.0	148.1	146.2	144.4	142.6	140.9	139.2	137.5
20 x 24	150.0	147.7	145.4	143.3	141.2	139.1	137.1	135.2	133.3	131.5	129.7	128.0	126.3	124.7	123.1	121.5	120.0	118.5	117.1	115.7	114.3
20 x 26	162.5	160.0	157.6	155.2	152.9	150.7	148.6	146.5	144.4	142.5	140.5	138.7	136.8	135.1	133.3	131.6	130.0	128.4	126.8	125.3	123.8
20 x 28	175.0	172.3	169.7	167.2	164.7	162.3	160.0	157.8	155.6	153.4	151.4	149.3	147.4	145.5	143.6	141.8	140.0	138.3	136.6	134.9	133.3
20 x 30	187.5	184.6	181.8	179.1	176.5	173.9	171.4	169.0	166.7	164.4	162.2	160.0	157.9	155.8	153.8	151.9	150.0	148.1	146.3	144.6	142.9
20 x 32	200.0	196.9	193.9	191.0	188.2	185.3	182.9	180.3	177.8	175.3	173.0	170.7	168.4	166.2	164.1	162.0	160.0	158.0	156.1	154.2	152.4
21 x 24	165.4	162.8	160.4	158.0	155.6	153.4	151.2	149.1	147.0	145.0	143.0	141.1	139.3	137.4	135.7	134.0	132.3	130.7	129.1	127.5	126.0
21 x 26	179.2	176.4	173.7	171.1	168.6	166.2	163.8	161.5	159.2	157.1	154.9	152.9	150.9	148.9	147.0	145.1	143.3	141.6	139.8	138.1	136.5
21 x 28	192.9	190.0	187.1	184.3	181.6	179.0	176.4	173.9	171.5	169.2	166.9	164.6	162.5	160.4	158.3	156.3	154.3	152.4	150.6	148.8	147.0
21 x 30	206.7	203.5	200.4	197.5	194.6	191.7	189.0	186.3	183.7	181.2	178.8	176.4	174.1	171.8	169.6	167.5	165.4	163.3	161.3	159.4	157.5
21 x 32	220.5	217.1	213.8	210.6	207.5	204.5	201.6	198.8	196.0	193.3	190.7	188.2	185.7	183.3	180.9	178.6	176.4	174.2	172.1	170.2	168.0
21 x 34	234.2	230.7	227.2	223.8	220.5	217.3	214.2	211.1	208.2	205.4	202.6	199.9	197.3	194.7	192.2	189.8	187.4	185.1	182.8	180.6	178.5
22 x 26	196.6	193.6	190.7	187.8	185.1	182.4	179.8	177.2	174.8	172.4											
22 x 28	211.7	208.5	205.3	202.3	199.3	196.4	193.6	190.9	188.2	185.6											
22 x 30	226.9	223.4	220.0	216.7	213.5	210.4	207.4	204.5	201.7	198.9											
23 x 30	248.0	244.1	240.4	236.8	233.4	230.0	226.7	223.5	220.4	217.4											
23 x 32	264.5	260.4	256.5	252.6	248.9	245.3	241.8	238.4	235.1	231.9											
23 x 34	281.0	276.7	272.5	268.4	264.5	260.7	256.9	253.3	249.8	246.4											
24 x 30	270.0	265.8	261.8	257.9	254.1	250.4	246.9	243.4	240.0	236.7											
24 x 32	288.0	283.6	279.3	275.1	271.1	267.1	263.3	259.6	256.0	252.5											
24 x 34	306.0	301.3	296.7	292.3	288.0	283.8	279.8	275.8	272.0	268.3											
25 x 32	312.5	307.7	303.0	298.5	294.1	289.8	285.7	281.6	277.7	273.9											

slipping, varies according to the condition of the rail, whether the surface is wet or dry, covered with snow or ice, sanded or clean. Considerable discrepancy exists in the figures given by the different authorities as to the exact relation between the adhesion on the rail and the weight on the wheels.

In a paper entitled "The Effect of Brakes upon Railway Trains," read by Captain Galton before the Institution of Mechanical Engineers, this authority says:

"On dry rails it was found that the co-efficient of adhesion of the wheels was generally over 0.20. In some cases it rose to 0.25 or even higher. On wet or greasy rails without sand, it fell as low as 0.15 in an experiment, but averaged about 0.18. With the use of sand on wet rails it was above 0.20 at all times; and when the sand was applied at the moment of starting so that the wind of the rotating wheels did not blow it away, it rose up to 0.35, and even above 0.40.

These experiments seem to be the most reliable that have been published. They agree with the conditions noted in running locomotives of various ratios of adhesion to weight on drivers. For all practical purposes the question may be thus summed up: The adhesion should not be assumed to be more than one-fourth of the weight on the driving wheels, and for

TABLE No. 3.

Boiler Pressure.	Percentages of Boiler Pressure.					
	83	84	85	86	87	88
140	116.20	117.60	119 00	120.40	121.80	123.20
145	120.35	121.80	123.25	124.70	126.15	127.60
150	124.50	126.00	127.50	129.00	130.50	132.00
155	128.65	130.20	131.75	133.30	134.85	136.40
160	132.80	134.40	136.00	137.60	139.20	140.80
165	136.95	138.60	140.25	141.90	143.55	145.20
170	141.10	142.80	144.50	146.20	147.90	149.60
175	145.25	147.00	148.75	150.50	152.25	154.00
180	149.40	151.20	153.00	154.80	156.60	158.40
185	153.55	155.40	157.25	159.10	160 95	162.80
190	157.70	159.60	161.50	164.40	165.30	167.20
195	161.85	163.80	165.75	168.70	169.65	171.60
200	166.00	168.00	170.00	172.00	174.00	176.00
205	170.15	172.20	174.25	176.30	178.35	180.40
210	174.30	176.40	178.50	180.60	182.70	184.80
215	178.45	180.60	182.75	184 90	187.05	189.20
220	182.60	184.80	187.00	189.20	191.40	173.60
225	186 75	189.00	191.25	193.50	195.75	178.00
230	190.90	193.20	195.50	197 80	200.10	184.40
235	195.05	197.40	199.75	202.10	204.45	186.80
240	199.20	201.60	204.00	206.40	208.80	191.20
245	203 35	205.80	208.25	210.70	213.15	195.60
250	207.50	210.00	212.50	215.00	217.50	220.00

ordinary conditions, less than one-fifth of the weight on the driving wheels—or expressed differently, the co-efficient of adhesion for locomotives should not be considered as more than 0.25 or less than 0.20. The working range of proportions existing between the weight on drivers and tractive force may be summed up in these two figures, except in the conditions noted below. The limitation of one-fifth is often exceeded in passenger engines with very large wheels. In such cases the amount of tractive force is a secondary consideration to the necessity of having cylinders small enough and a boiler large enough, so that the amount of steam which the boiler can generate will be ample for the varying conditions of fast passenger service. No useful end seems to be gained, so far as the adhesion is concerned, by making the tractive force less than one-fifth of the weight on the drivers.

The co-efficient of adhesion existing between a revolving wheel and the rail is independent of the velocity. It is practically constant for all speeds, and only varies according to the character of the surfaces in contact. A very marked distinction must be made between the co-efficient of adhesion when the wheels are rolling and the co-efficient when the wheels commence to slip. In the first case the minute projections and depressions existing in the tire and rail may be said to fit into each other as the wheel rolls on the surface of the rail, interlocking, as it were, in a somewhat similar manner to a rack and pinion. After the wheel commences to slip, the resistance decreases rapidly as the speed increases in a similar manner to the well-known facts regarding the variation of friction existing between a brake shoe in contact with a wheel revolving at different velocities.

The very great decrease in friction when a wheel commences to slip is perhaps best shown by further reference to Captain Galton's experiments.

Although these co-efficients were obtained from slid steel tired wheels on steel rails, where the wheels were held from revolving by the brake shoes, and the stationary wheels were, therefore, drawn along the rails, yet it is thought the results are about the same as if the wheels were revolved in the same spot without moving along the rails. The following table gives approximately the co-efficient of friction derived from these experiments:

Dynamic Friction Between Wheel and Rail.

Approximate velocity.		Co-efficient of friction. Steel tire steel rail.
Feet per second.	Miles per hour.	
Just coming to rest		.242
10	6.8	.088
20	13.6	.072
40	27.3	.070
50	34.1	.063
60	40.9	.057
70	47.7	.040
80	54.5	.038
88	60.0	.027

To obtain the best results in starting or when pulling the maximum load, it is evident that the tractive force should always be somewhat less than the minimum adhesion. At the moment of slipping the co-efficient of adhesion decreases to such an extent that it is necessary at once to shut the throttle until the wheels cease to slip. By using sand it is possible to get over short stretches of wet, slippery track, but the weight on the drivers should always be sufficient to "hold the engine to the track" under ordinary conditions of service.

A mistake in the engraving of Fig. 1 in Mr. Coles' article on "Mean Effective Pressure and Horse-Power," page 176 of the June issue of this paper, has just come to our notice. The words "Percentage of Increase of Speed," were wrongly added by the engraver to this diagram. They apply to Fig. 4, but not to Fig. 1.

DEFECTS IN PILOT AND TENDER COUPLERS.

Notwithstanding the number of different designs of couplers, a committee of the Southern and Southwestern Railway Club finds that "none of the manufacturers of automatic couplers for front ends of engines or back ends of tenders have as yet supplied the wants of the service for which they are intended."

A more flexible and elastic coupler is desired with limited vertical and lateral motion to prevent the excessive wear of knuckles and guardarms. This is particularly important where double heading is practiced, because of the constant vibration of the couplers. The semi-rigid type is criticised because of breakage of fastenings and drawbars as a result of the rigidity. The solid castings so often used at the rear ends of tenders are also too rigid. They frequently break in a way to make temporary repairs impossible and they cannot be used successfully on curves of more than 7 degrees.

This committee does not favor the drop or swing type of pilot coupler because when made strong enough for double heading they are unwieldy and heavy. The danger of cattle being knocked down by the bull-nose type of pilot coupler seems to the committee too remote to render this simple type objectionable.

In the opinion of this committee the most desirable form of coupler for double-heading would consist of the standard automatic coupler, with the buffer block and yoke as per M. C. B. drawing No. 11, for both pilot and tender, the details of attachment to tender to be such as the height of the engine and tender might require to maintain the standard height; the question of vertical and lateral motion to be allowed to be determined by the topography and curvature of the particular locality in which the device was to be used, but in general it is the opinion of the committee that the flexibility allowed as per M. C. B. recommended practice, drawing B, will be found sufficient.

* This is from a mean of three experiments only.

EXPRESS CAR FOR TRANSPORTATION OF HORSES.

New York Central & Hudson River Railroad.

The statistics of the larger express companies show a great increase during the last few years in the transportation of horses by express in passenger trains. This increase is undoubtedly stimulated if not entirely caused by improvements in methods of caring for horses on trains, and on a number of roads it has been found necessary to provide special equipment for this purpose. As owners of expensive horses are exceedingly critical of the accommodations the railroads have devoted considerable attention to the arrangement of these cars, and as they have been obliged to provide for this traffic in cars which are used for a large part of the time for other business the problem is rather an interesting one.

Through the courtesy of Mr. A. M. Waitt, Superintendent of Motive Power of the New York Central & Hudson River Railroad, we have received drawings showing the arrangement of ten new cars for the transportation of horses and other express business, which have just been built at the West Albany shops. The details of this design were worked out by Mr. F. M. Whyte, Mechanical Engineer of the road, under the direction of Mr. Waitt.

The officers of the American and National Express Companies expressed to the writer their entire approval of this construction. The easy riding qualities of the cars are especially appreciated. The car bodies are the same as the standard 60-ft. express cars of the road, except that at one end an 8-ft. door is provided, the door at the other end being 4 ft. 6 in. wide; the trucks are the standard 6-wheel type for passenger equipment, which accounts for the easy riding. The design throughout shows care to make a convenient arrangement of the movable partitions, the desired result being the best possible car for horses without causing inconvenience when used in other business.

Each of the cars will carry 16 horses. The arrangement of stalls is shown in Fig. 1. There is a section for four horses at each end of the car, and a double section for eight more at the center. Fig. 4 shows the form of the stall partitions, and it will be seen that cast-iron projections at the lower ends of the posts fit into holes in the floor to locate and secure the posts at the bottom. The upper ends are secured to partition supports of 2-in. pipe, extending across the car over the stalls and supported in iron fixtures. The posts are secured by pins, and when the car is wanted for other purposes the partitions are raised a little and moved along the floor to one side of the car, where they are out of the way. The pipe portions of the cross bars are then taken down and are carried upon the permanent portion shown at the left in Fig. 3, which is made in the form of a hook to receive and hold them. In this condition the car is unincumbered and unobstructed, except as regards the space occupied by the partitions, which are closed against the wall. There are no loose pins, keys or fittings, no bolts or nuts to be turned, and the whole arrangement is most convenient. At the center of the car gates are fitted, and the smaller one may be swung for the convenience of the attendants when the stalls opposite the small gate are not occupied. There is no padding whatever about the car, but great care has been taken to leave no sharp corners exposed. The detail of the partition shows that the horse's head comes far enough to the left, as shown in this view, to avoid hitting the cross bar, and this engraving also shows the partitions to be high enough to prevent the horses from reaching their heads over them. The large door is for carriages. The cars are provided with Pintsch gas and steam heat, and they are also ventilated,

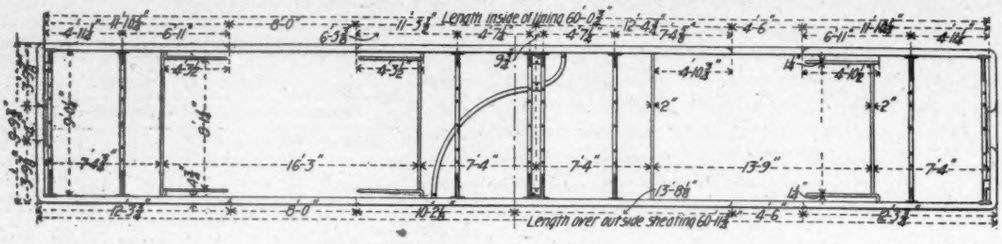


Fig. 1.—Floor Plan.

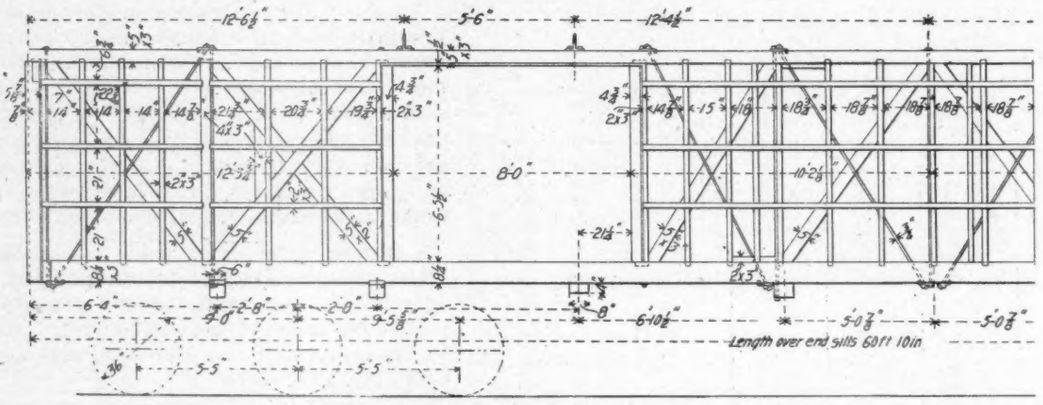


Fig. 2.—Framing of Car.

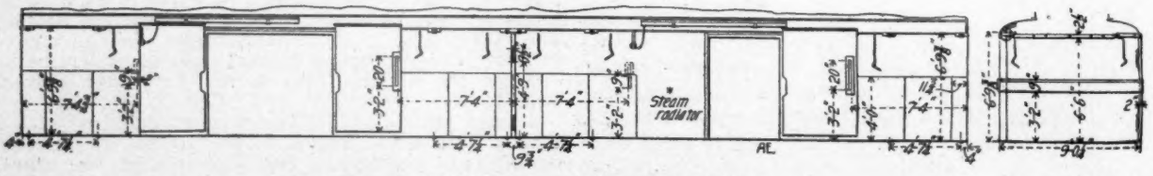


Fig. 3.—Side Elevation (Inside) and Section.

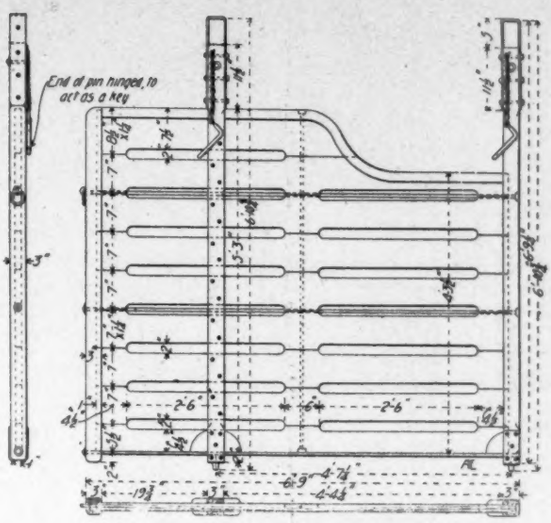


Fig. 4.—Details of Partition.

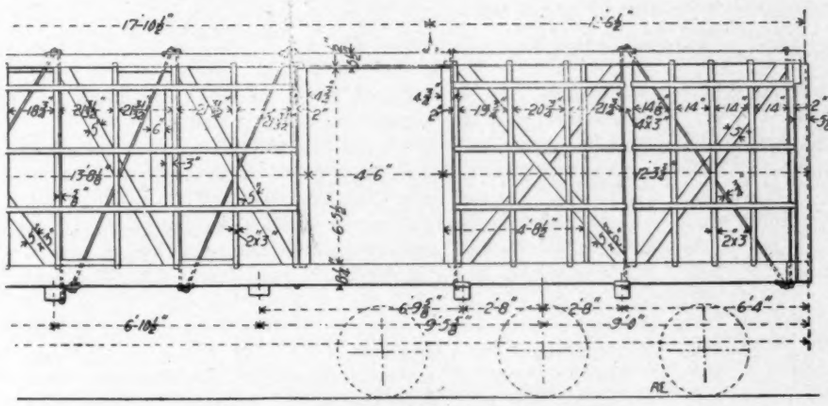


Fig. 2.—Framing of Car.

special care being taken to prevent drafts. A bridge for loading horses upon the cars is ingeniously arranged to be slung under the car on top of the truss rods. It is obvious that the partitions and cross bars may be kept at terminals, where they can be applied when necessary, but it is understood that they will be kept in the cars ready for use at any time.

Plush-covered seats, intricate fret and grillework, carved panels, carpets and boxed heating pipes are to be excluded from all future passenger equipment of the Big Four and Chesapeake & Ohio as a sanitary measure.

Reviewing the exhibits of locomotives at the Paris Exposition in the "Engineering Magazine," Mr. Charles Rous-Martin mentions the following points which seem to him most significant:

The enormous preponderance of the compound type of engine over the simple high-pressure type.

The comparative scarcity of eccentricities in design.

The immense increase in size and weight of locomotives since the last Exposition.

The specially huge size and power of certain Russian engines.

The almost universal employment of coupled wheels in express engines and the consequent all but complete disappearance of the single-driven type.

The large augmentation of heating surface and steam pressure.

TEMPERATURE AND FRICTION OF BRAKE SHOES.

An investigation of the effect of increase of temperature upon the friction of brake shoes which throws more light upon the subject than it has ever before received is recorded in a paper by Prof. R. A. Smart, of Purdue University, read last month before the Western Railway Club. The experiments appear to have an important bearing upon the prospective specifications of the M. C. B. Association for brake shoes. The paper is admirably arranged and thoroughly illustrated by aid of diagrams. The conclusions are summarized as follows:

So far as the writer is aware, no reliable information has been obtained heretofore on the effects of temperature, a fact which is easily explained by the difficulties attending such investigations. In fact, it is wellnigh impossible to carry out the experiments with a great degree of refinement or to arrive at other than general conclusions. This, however, has been done in the investigation under consideration, and the general conclusion reached is put forth with confidence as one which is accurate for all practical purposes.

The tests upon which the conclusion is based involve ranges of temperature of the shoe up to 1,500 degrees Fahr., speeds of from 40 to 60 miles per hour, and normal pressures of from 2,800 pounds to 6,840 pounds. They also involve continuous runs of about five miles in length and from five to ten minutes in duration. It is believed that the range of temperature mentioned is sufficiently high to embrace all but the most extreme conditions of service.

The conclusion drawn from these results confirms the one already stated; i. e., that within the limits of the tests the temperature of the rubbing surface does not affect the coefficient of friction.

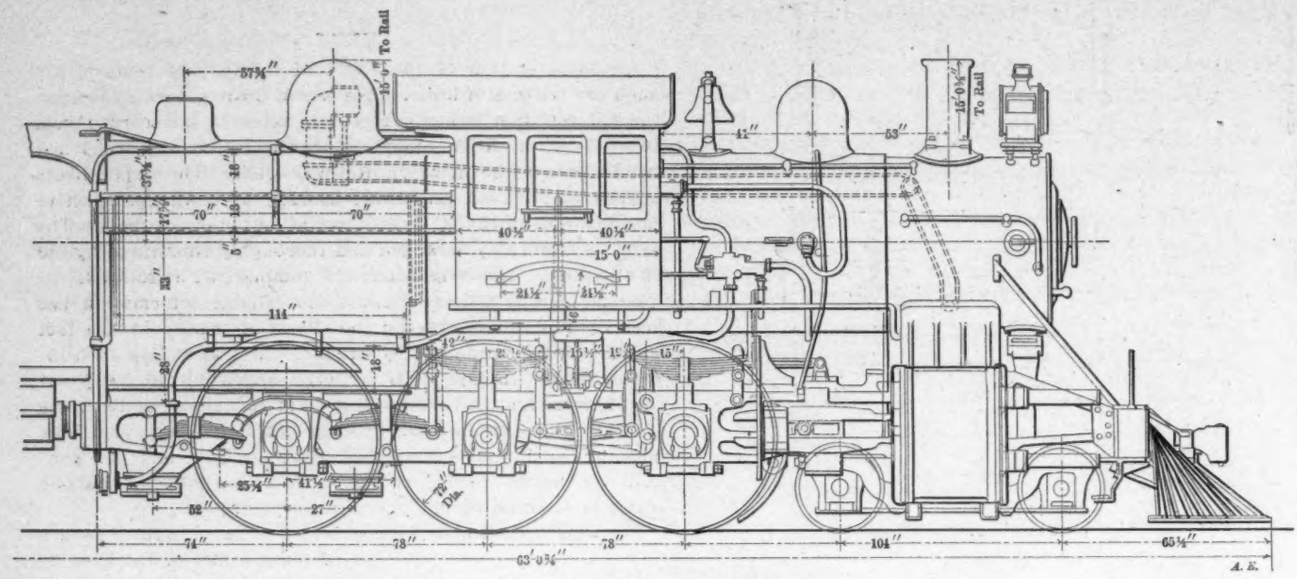
The coefficient of friction of brake shoes decreases with increase of pressure.

The coefficient of friction of brake shoes decreases with increase of speed, except from about ten to twenty miles per hour, between which speeds it increases slightly.

The coefficient of friction of cast-iron brake shoes is practically constant with variations in temperature of shoe and wheel within the limits of the experiments.

In view of the variable action of the majority of brake shoes while under test, it seems to the writer that it would be unwise to attempt to specify very narrow limits for the frictional qualities of shoes. A possible plan would be to choose some standard speed (or, possibly, two speeds) and prescribe a range of performance for different pressures within which the mean coefficient of friction of all shoes must come.

In order further to insure a sufficient degree of uniformity in the friction of each shoe during the length of the application, it should be specified that the coefficient of friction at a certain number of feet, after the application commenced, should not be less than such a per cent. of the mean coefficient of friction, and that the coefficient of friction a certain number of feet from the stop should not be more than a certain per cent. above the mean coefficient of friction, and should be less than a certain fixed limit. This arrangement would provide an element of elasticity which would cover the unavoidable variations in the results of tests, and at the same time would secure a degree of uniformity which would, in great measure, remedy existing evils.



Wide Fireboxes and Large Driving Wheels.

A New Design for Passenger Service—Lehigh Valley Railroad.

WIDE FIREBOXES AND LARGE DRIVING WHEELS.

The tendency toward the use of wide fireboxes for bituminous coal-burning engines is becoming pronounced, and many indications point to a general adoption of this practice. It is rather radical, but we have not yet heard a single unfavorable criticism of either the "Prairie" or "Northwestern" types as far as the size of the firebox is concerned, and we know of three entirely different designs of wide firebox engines for soft coal which are likely to appear during the approaching winter. We believe this to be a very important step in locomotive design, and it should be studied most carefully. Much has been said about having nearly approached the limits of weight and power (particularly of fast passenger engines), but it seems probable that the use of larger grate areas places the time for reaching the limits further into the future.

It is perfectly natural to turn to new wheel arrangements in the desire to use wide grates, and this tendency has and probably will continue to explain the appearance of a number of interesting locomotive designs. It seems to be an appropriate time to raise the question whether or not existing types, such as the eight-wheel, Atlantic, and 10-wheel arrangements will not suffice, and whether they will not all work out satisfactorily with wider grates. As to the Atlantic type there is no question but it would be well to try the other two-wheel arrangements with the large grates.

This suggestion inyolves the difficulties of high boilers and shallow fireboxes, but since a large amount of passenger service is too heavy for anything less than a six-coupled engine it seems worth while to experiment in both of these directions. The necessity for deep fireboxes for soft coal is strongly urged by many designers, but the question whether the advantages of depth may not be obtained by shallow boxes made longer and fitted with bridge walls does not seem to be settled, and it may be found that large wheels and wide fireboxes can be combined without inconvenience or loss in combustion due to short flame-way in a vertical direction.

The recent ten-wheel designs for hard coal on the Delaware, Lackawanna & Western, the Central Railroad of New Jersey and the Lehigh Valley, illustrated in our September number and in the present issue, are commended to the attention of those who are designing wide firebox passenger engines for soft coal burning. In the case of the Lehigh Valley 72-in. driving wheels are placed under a firebox 7 ft. 6 ins. wide. Mr. F. F. Gaines, Mechanical Engineer of this road, expresses his opinion on this subject in a recent communication as follows:

To the Editor:.

In reading your article on page 92 of the September issue, "What is the Ideal Fast Passenger Engine?" it occurs to me that a 10-wheel type of engine with a wide firebox and an 84-in. driver is not altogether out of the question. I enclose you blue prints [Two of which are reproduced—Editor] showing the side elevation and the cross-sections and elevations of the boiler for a 10-wheel engine having 72-in. driving wheels and a firebox 7 ft. 6 ins. wide.

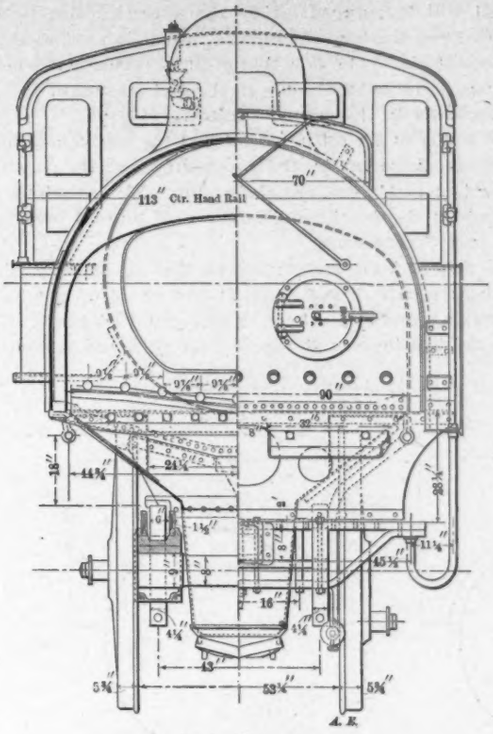
The drawings in question are for 10-wheel engines that are to be built in the near future for this road, and are to be used in heavy passenger service between Easton and Wilkes-Barre; they are intended to handle our heavy through trains between these points without the aid of a helper, where now we have to have a helper from Mauch Chunk to Wilkes-Barre.

The engines, as you will observe, are four-cylinder compounds having cylinders 17 and 28 by 26 ins.; the boiler is 64 ins. in diameter, of the wide firebox type, to carry 200 lbs. of steam; the grate area is 71.25 sq. ft.; heating surface of tubes, 2,536.59 sq. ft.; heating surface of the firebox, 171.71 sq. ft.; total, 2,708.3 sq. ft. The drivers are 72 ins. in diameter over tires; main journal, 10 by 12 ins.; front and back journal, 9 by 12 ins.; and engine truck journal, 6 by 12 in. The weight on drivers is 130,000 lbs., and the weight on the truck 45,000 lbs.

Owing to the limiting weight on drivers, in order that the boiler as shown might be used, it was necessary to figure very closely on the weights of the remaining parts, and with this end in view, cast steel has been largely used. The frames, driving wheel centers, equalizers, guides, grate bearer, rockers and driving boxes all being steel castings, phosphor bronze shoes and wedges are used in connection with the steel driving boxes.

The center of the boiler above the rail is 110 ins. In the September issue of your paper the D., L. & W. engine shown gives this distance as 114 ins. By taking the engine in question, and raising the boiler 4 ins. higher we could increase the driving wheels in diameter the same amount, which would then give us driving wheels 76 ins. in diameter.

By inspection of the boiler you will readily see that by either using a combustion chamber and brick wall, or by using a brick arch of the general type used in soft coal engines, we would be able to raise our grates fully 8 ins. higher, and



Section Through F rebox.

accordingly increase our driving wheels the same amount, which would then give us an 84-in. driving wheel. I do not consider the problem at all impossible, but practical, if the circumstances demand it, although it involves the use of either the combustion chamber or brick arch to attain the end in view, either of which, in my estimation, should not be used, unless the necessity is very great for the large diameter of driving wheel. An engine with drivers 76 ins. in diameter, which can be obtained in the 10-wheel type without going to the brick arch or combustion chamber, will haul a heavy train at a sufficiently high speed for all practical purposes, if this type of engine is desirable.

I think, however, in comparing the Atlantic and 10-wheel types of engine, some of the principal advantages of the Atlantic type have been overlooked entirely; with the Atlantic type sufficient tractive power can be obtained on two pairs of drivers to haul any reasonable weight of train, as only in starting will the maximum adhesion forces be brought into play, and that only for a few moments—by the use of sand sufficient adhesion can be obtained to start the heaviest trains—and when once started the tractive power rapidly drops down, due to working the engine at shorter cut-offs, so that the relation between cylinder tractive power and adhesion is well within the limits of good design.

I might say further, in regard to the Atlantic type, that with engines on heavy fast-passenger trains, the limiting factor, as far as power is concerned, is the boiler, and that in nine cases out of ten the actual tractive power is not a factor. The problem then presents itself of providing a boiler of sufficient size to provide steam for heavy fast runs; if such a boiler could be carried safely on two pairs of driving wheels, it would undoubtedly make the ideal engine, but experience has shown that it cannot be so carried, consequently the question resolves itself into a choice of the use of one of two designs, either the 10-wheeler or the Atlantic type. For exceedingly heavy trains, where the actual tractive power may be a factor, then of course it requires the 10-wheel type, but where it is not so much a question of tractive power as it is the free supply of steam at a high pressure in large quantities, the problem is much better solved, for the reasons already given, by the use of the Atlantic type.

The foregoing being true, the advantages of the Atlantic type are incontestable in that the rod connections are fewer and the rigidity of the engine is less; consequently the cost of repairs and liability of failure are both greatly reduced. Both of these items being of enough importance in my estimation to consider the Atlantic type of engine for a good many years to come as the best type for fast passenger service.

F. F. GAINES,
Mechanical Engineer, Lehigh Valley Railroad.

HOT JOURNALS.

From the Standpoint of Oil Pressures Between Bearing Surfaces.

While it is difficult to say anything really new in regard to lubrication of journals it is clear that one phase of the subject is comparatively little understood, although there are evidences of the appreciation of difficulties in connection with it. The proper method of getting oil to the journals is referred to. It has long been understood that the pressure is greatest near the top of the bearing of railroad axles, and doubtless a great deal of the difficulty with hot boxes may be overcome when this fact is appreciated in its relation to the proper method of getting oil to the bearing surfaces.. It seems clear that locomotive driving journals need a little different treatment from that which they have usually received. Recently a review of the subject of hot bearings by Mr. Josef Grossmann, Inspector of the Northwestern Railroad of Austria, appeared in an Austrian publication* for a translation of which we are indebted to Mr. A. Christianson. This review is commended to our readers because Mr. Grossmann discusses a subject of special interest in its application to driving journal lubrication.

The question is to design bearings so as to bring the lubricating oil between the journal and the bearing and prevent it from working out. The chief cause of hot bearings is a deficiency of lubrication. Fig. 1 represents two bodies between which a layer of lubricating oil, m n, is drawn to an enlarged scale. The lubricant may be imagined to take the form of a series of a parallel oil layers, of which those nearest the metallic surfaces are held by a strong capillary force, drawing the oil into the pores of the metal. The oil layers between these furnish material upon the sliding process is carried out and the resistance of the oil layers against the motion of the two bodies constitutes the frictional resistance. Petroff has demonstrated that the conduct of the different oil layers by the sliding movement of two solid bodies is similar to the action of different liquids in a Poiseuilleshe's tube; that is, as soon as sliding begins the middle layers, which move easiest, have the highest velocity and the velocities decrease until the outside layers are reached and these being in contact with the sliding surfaces do not move at all with reference to those surfaces. It is necessary to insure the presence of the middle layers in order to avoid a retardation of motion and consequent friction. On the application of pressure to a bearing some of the middle layers will be forced out and the outside layers will come closer together, which necessitates the replacement of the middle layers with new oil. If this is not done the bearing surfaces will come closer and closer together until the danger of a hot bearing is reached and finally even the outside layers may be scraped off, giving direct contact between the surfaces, which is sure to cause trouble.

The load per square inch in Austrian railroad practice varies between 450 and 750 lbs., increasing at times to 1,185 lbs.; for tenders it is sometimes as high as 1,575 lbs. It is apparent that the oiling process in a great majority of railroad bearings take place under unfavorable conditions. A journal and bearing with the oil layer drawn to an enlarged scale is shown in Fig. 2. It is clear that each part of the bearing transmits load to the journal in proportion to its projection upon the journal and that the major part of the transfer is at the crown, where the greatest wear will occur. If the oil layer is taken away and the bearing placed directly upon the journal the bearing will transfer the load only through two narrow surfaces, Fig. 3. But if the bearing is not exceedingly strong it will spring and cramp the journal. If strong enough the greatest pressure will be at a b. When oil is brought to the bearing surface at the place where there is no load it may not be able to get in between the bearing surfaces, the pressure on the sides of the journal may be great enough to prevent the entrance of oil,

*Zeitschrift des Oesterr. Ingenieur.

which is at once sufficient cause for heating. It will be understood that the space between the journal and the bearing in a radial direction will be very small at most, merely the thickness of the oil. The cramping of bearings was first brought to the author's attention through Mr. Woodbury's paper before the American Society of Mechanical Engineers in 1885. In 1884 Herr Helmholz of Hanover called attention to the fact that the journal bearing of a roll after running hot had contracted so much toward the journal that a piece of tin could be passed between the journal bearing and the frame jaw in which it fitted closely before the heating. In his opinion the closing up on the journal was the cause for hot running and to remedy this the bearing of Fig. 4 was used in which bolts were employed to prevent the gripping of the journal. The author's method for overcoming this difficulty will be referred to later. His idea is shown in Fig. 10. It is not unlike the method of providing clearance on trucks and driving brasses on some American roads.

The location of the oil cavities and leaders has much to do with hot bearings. A distribution of the oil is very unsatisfactory in the usual method, because the oil leaders are generally located in the area of greatest load. The grooves soon wear to sharp edges by which the oil is scraped from the bearing surface and forced up through the oil hole if this is located at the top of the bearing. If the oiling is done from below by a swab or packing, Fig. 5, and the bearing is made of such shape as to avoid the closing in, at least the front half will be oiled. The other half will run more or less dry, because the lubricating oil will be scraped off by the edge, k. But if the oiling is done from the top, as in Fig. 6, no oil can get to the bearing surfaces at all. [The fact that oil does occasionally get to such bearings is undoubtedly due to the end motion of the journals, and probably to this alone.—Editor.]

The action of the oil in oil holes at the top of bearings loaded on top is discussed in the proceedings of the Institution of Mechanical Engineers (England) for 1883, describing exhaustive tests of the frictional resistance of journal bearings lubricated in different ways.

The fact is here communicated that in spite of oil leaders and the presence of sufficient oil, not one drop got in between the bearing surfaces, where it was expected to go. The tests employed bearings as shown in Figs. 7, 8 and 9, also different oil cups were used. Hot running always took place with a journal having an oil cavity arranged as shown in Fig. 7, even with a load of 105 lbs. per square inch, but when the load was removed for only a moment some oil got in between the bearing surfaces to be again forced out upon the application of the load and the oil raised immediately to its former height in the oil cup. Even the rounding off of the edges of the oil cavity did not suffice, and the test proved that no oil could get between the bearing surfaces under these conditions.

With the bearing of Fig. 8, oiling took place up to a load of 400 lbs. per square inch when heating commenced. The bearing shown in Fig. 9 was then tried, the oil leaders being the same as used in British locomotive practice, but this journal also refused to take oil, even when the oil column was in-

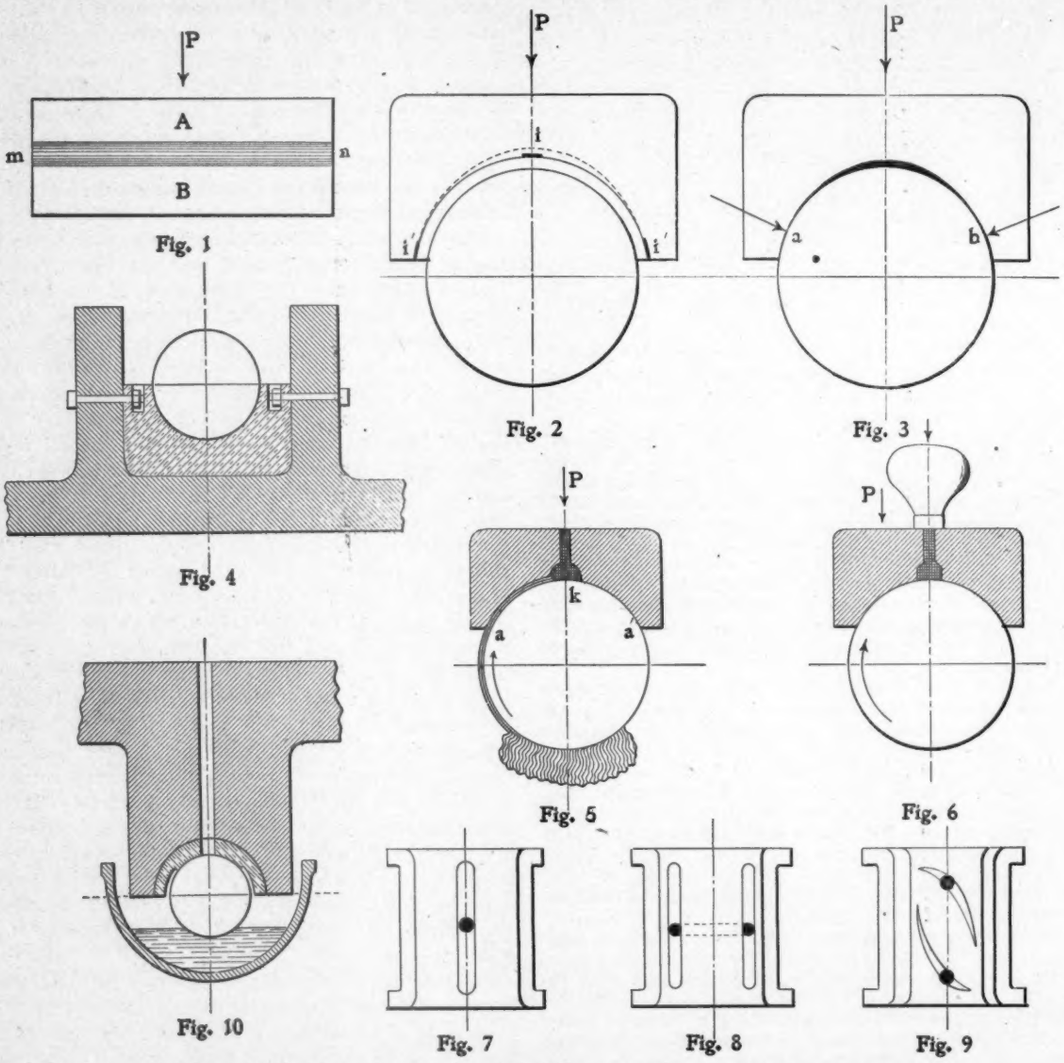


Fig. 1 Fig. 2 Fig. 3

Fig. 4 Fig. 5 Fig. 6

Fig. 10 Fig. 7 Fig. 8 Fig. 9

Hot Journals from the Standpoint of Oil Pressures Between Bearing Surfaces.

creased to a height of 10 ins. This bearing ran hot with a load of 200 lbs. per square inch. After repeated tests it was found that nothing would suffice but to oil the journal from below.

The clamping action of the bearing and the behavior of the oil leaders led Mr. Grossmann to recommend a bearing with a very narrow bearing area, which did not sufficiently surround the journal to permit of closing in upon it. The oil grooves were left out entirely and the oil applied to the unloaded part of the journal by dipping into an oil bath or coming into contact with oily waste. Another form of the bearing suggested is shown in Figs. 12 and 13, in which it is exhibited in a form adapted for oiling from the top. Several holes are drilled through the crown of the bearing, but these are not for the passage of oil downward to the journal. They act to take oil up from the journal to the top of the bearing, from which it runs down through the grooves upon the outside of the bearing and reaches the journal where it has no load.

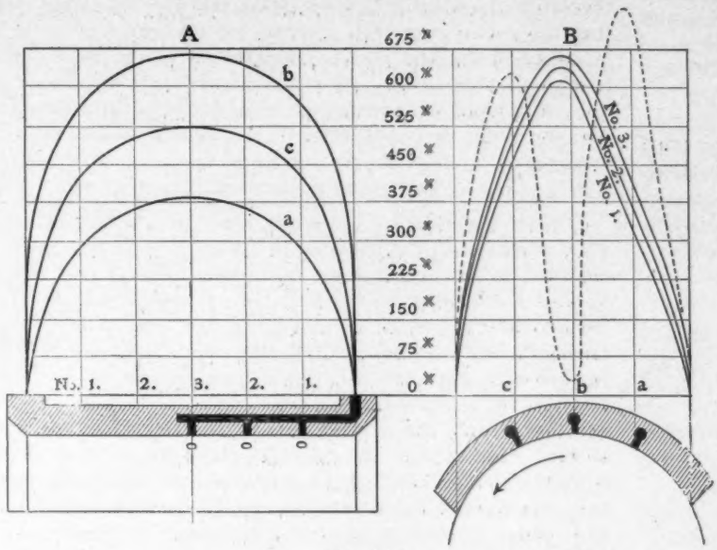


Fig. 11

The phenomenon of oil driven upward from the bearing as in this case is not new. It is due to the pressure of the oil layers and the oil can only be removed by a large force. The resistance of the oil layers to the load causes the pressure, which is proportional to the load. The London tests referred to included the measure of these pressures with the results given in the diagrams. The tests were made with an ordinary railroad car axle, the journal of which was arranged as in Fig. 10, with an oil hole drilled through the center of the bearing. In the first test the oil hole was not used, the oiling being done from below by an oil bath, and it was observed that the oil raised in the oil hole above, and upon the application of a gauge a pressure of 200 lbs. per square inch was discovered with a load of only 100 lbs. per square inch of the horizontal projection of the journal. The conclusion was that the pressure of oil between the journal and the bearing was a maximum at a line near the center of the bearing, decreasing to zero at the ends and lower edges and the pressures were systematically measured.

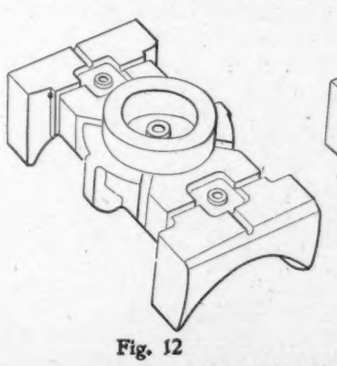


Fig. 12

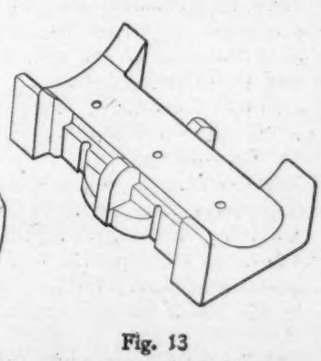


Fig. 13

This was done with a 4 by 6 in. journal and a bearing having three small holes drilled from the outside face to the center lengthwise of the bearing. Gauges were connected to these by copper pipes and the pressures were taken by means of holes bored through the bearing into these longitudinal holes, so that the gauge was put into communication with the oil layer at different points, as in Fig. 11. The observations were taken separately and the holes carefully closed up after they were used.

The bearing carried a total load of 7,980 lbs., the journal made 100 revolutions per minute, the temperature was 90 degrees and the oiling was done by an oil bath from below. The observed pressures registered as follows:

In cross section	a	b	c
No. 1	326	585	452
No. 2	373	647	510
No. 3	389	658	526

Fig. 11A shows the pressure in the longitudinal direction, whereas Fig. 11B shows the pressure in the cross-section Nos. 1, 2 and 3. From the plotted curves the pressure in the six planes is shown. The pressure in the crown of curve b is larger than that of the curves a and c on either side. The total load figured from these curves was 7,959 lbs., which is a difference of 21 lbs. from the actual load.

An increase or decrease in the load caused a corresponding change in the pressure of the oil layer, but the pressure did not seem to be affected by a change of speed from 150 to 200 revolutions per minute. The bearing used in this test was perfectly smooth; that is, without oil cavities or leaders. With an oil cavity at the center the highest curve will fall out entirely, because of the presence of the oil cavity, which accounts for the falling off in the center of the curve indicated by the dotted line in Fig. 11B at the crown of the bearing, where otherwise the highest pressure would occur. It is obvious that the oil layer is considerably affected by the scraping action of the edge of the oil cavity and the unfavorable condition of this arrangement of bearing is clearly demonstrated.

The journal bearing recommended by the author of this paper employs a narrow bearing surface, which is free from oil cavities and oil leaders. It utilizes the pressure of the oil layers to force small quantities of oil to the back of the bearing, from which it runs through grooves to the journal below the brass, thus providing a circulation of oil. The three narrow lugs on each side of the bearing are to prevent it from being thrown out of place with the application of the brake. These bearings have been in use for three years in Austria with favorable results.

[The report of the Committee on Journal Bearings, Cylinder Details and Lubrication before the Master Mechanics' Association last June, of which Mr. W. C. Dallas was Chairman, records interesting experiments in the direction of omitting the top oiling of driving boxes.—Editor.]

The Lake Shore & Michigan Southern Railway gave an order to the Brooks Locomotive Works early in July for two large passenger engines with wide fireboxes. In many details the engines will be the same as the 10-wheel passenger engines now running on that road. A 2-wheel truck will, however, be substituted for the 4-wheel leading truck, and there will be a 2-wheel radial truck under the firebox, making the engine similar to the Prairie type. The engines will have three pairs of 80-in. drivers, 20 x 28-in. cylinders, 49 sq. ft. of grate and about 3,250 sq. ft. of heating surface, and the boilers will carry 200 lbs. pressure. Total weight of engine is estimated at 174,000 lbs., of which 128,000 lbs. will be on the drivers. The engines will be delivered early in December.

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Contributions.—*Articles relating to railway rolling stock construction and management and kindred topics, by those who are practically acquainted with these subjects, are specially desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

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The trial of locomotives on roads other than those for which they are built is to be commended. It is important, however, that the trials should be made in the right spirit and with a view of learning facts rather than upholding one's own designs. The recent comparison of the new "Northwestern Type" locomotive with two standard engines on the New York Central, referred to elsewhere in this issue, is a unique case through which valuable information was obtained. The broad and liberal view of the idea taken by Mr. Waitt in permitting the publication of the results is particularly pleasing in view of the fact that the new design appeared to advantage beside his own. Such a comparison is as valuable as it is unusual.

Several promising improvements have recently been made in driving boxes with particular reference to methods of lubrication, and as the increasing weights and consequently increasing sizes of journals make this an exceedingly important subject, we have secured drawings showing some of them, and they will be published in future issues. Elsewhere in this issue is a review of a paper on the subject of lubrication to which the attention of motive power officers is earnestly invited. It seems to have been sufficiently demonstrated that the usual method of oiling driving journals through holes in the crown of the brass is not the best practice, because the pressure of the oil in the bearing is greatest at the top. It seems clear that the reason why such journals are lubricated at all is to be found in the end play or longitudinal motion, due to the clearance in the boxes. We will endeavor to show how the oil may be brought to the bearings satisfactorily and the number of hot driving boxes reduced, if the trouble is not entirely overcome.

Cylinder bushings are quite commonly used in repair work. They are frequently applied when cylinders wear too large in diameter to correspond with the driving wheels and boilers but, as indicated by Mr. F. E. Seley, in another column, they seem to offer important advantages in new construction. Some roads, notably the Chicago & Northwestern and Chicago, Milwaukee & St. Paul, use bushings in new locomotives and from the start the cylinders are placed in condition favorable to satisfactory wear. The bushings are inexpensive, they are made of good wearing iron; the cylinders may then be made strong without reference to wearing qualities and we should think that this practice would greatly simplify the foundry problems and reduce the number of broken cylinders. In answer to recent inquiries Mr. Bush, of the Chicago, Milwaukee & St. Paul, and Mr. Barr, of the Baltimore & Ohio, speak in positive terms of the practice. Mr. Bush uses cylinder bushings generally and considers them very desirable from a standpoint of economy. He says: "We are able to provide a thoroughly satisfactory metal for the bushings and also avoid the necessity for renewing cylinders." Mr. Barr has had a long experience with bushings and believes that they, and also false valve seats, should be used in order to get the right kind of material in the body of the cylinder and valve seat which will give the best wearing surface. He says that this cannot be accomplished in any other way. The practice will probably extend.

The expression "experimental stage" is very often used in a sense which seems to us unfortunate. Recently the status of the compound locomotive and of the piston valve have been described by it and nothing could be further from the facts. These improvements are no longer experimental in their fundamentals, no matter what their imperfections may be. The good standing of the principles which they represent were established long ago and it is only in the details that there is anything tentative or experimental. Considerable impatience is justified when motive power men say that they are waiting for these things to be perfected before they take them up. Valuable time is lost in delay and hesitation to make use of improvements so well understood as these when the advantages are so great and so apparent. It seems strange that anyone who is in a position to take a hand in the development and adoption of these principles can refuse to do so. Has not every motive power officer a duty to his company in this?

Arrangements for dealing with repairs to locomotive trucks in many of the older shop plants seem to be capable of improvement. This work is often done in the general repair shop and at the front end of the pits upon which the engines are standing. It seems desirable to provide a part of the shop with facilities specially intended for truck repairs and transfer all trucks to that place when the engines are dismantled. There are at least three reasons for considering such a plan. The truck work may be done better and quicker with the proper facilities. The tools are kept in one place and the work brought to them by cheap labor and space in front of the engine is saved for other purposes. This idea is carried out very

nicely in the tender shop of the Chicago & Northwestern (American Engineer, April, 1900, page 109), and a similar plan has been in use for years in passenger car repair shops.

NOTES.

Purdue University entered upon a new school year on Wednesday, September 12th, with a larger number of students in attendance than ever before in its history. The enrollment of the freshman class was approaching close to three hundred on the second day, with many new students yet to be matriculated. The number of freshmen will reach three hundred and fifty, and the total enrollment for the year will exceed one thousand. It is significant that the increase in the attendance is very largely within the schools of engineering. Preparations have been made during the summer in anticipation of a large attendance. Laboratory equipment in many departments has been increased, and one-half of the large building hitherto known as the men's dormitory has been so remodeled as to supply a dozen excellent additional recitation rooms. Both the newcomers and the old are, therefore, being well cared for.

The pneumatic fire kindler is an important piece of apparatus in the roundhouse. It is simply a compressed-air oil burner of the simplest construction, but of a usefulness entirely out of proportion to its simplicity. It is used above the coal, and without any kindling material. Some of the results of tests conducted by the mechanical engineering department of the University of Illinois with this instrument may be of interest. The tests were made to determine the relative costs of kindling fires by wood and by crude petroleum, the latter being burned by means of a fire kindler. The boiler pressure raised in each case was the same; the time required to reach this pressure was one hour and ten minutes kindling by oil and one hour and 44 minutes kindling by wood. The total cost, which in each case includes cost of labor, coal and the kindling material, amounts to 34 cents for oil and 61 cents for wood, on a basis of oil at 2¼ cents per gallon, and coal 75 cents per ton—a gain in favor of the oil of about 45 per cent.—Edward C. Schmidt, St. Louis Railway Club.

AN EXCURSION TO THE AMERICAN TROSACHS.

A number of members of the New York Railroad Club were the recipients in early September of invitations, issued under the name of its Executive Committee, "To visit the picturesque and historic mountains and valleys of the Ramapo on Saturday, September 15th." The excursion was in reality given by Mr. W. W. Snow, the Chairman of the committee.

In response to his hospitality about fifty members met in the Erie Railroad station in Jersey City soon after nine o'clock on the date named, and were received by their host and conducted to a special car, which was attached to the express train. From there they were taken by railroad to Tuxedo Park, and, as the French say, they then "descended" and took carriages which were provided, and the guests were driven through the park and around its beautiful lake, and all enjoyed the ride in the shaded roads, through the charming glens and over the breeze-ladened hills of that picturesque region. To nearly all the visitors Tuxedo Park was a revelation. Some of them had, it is true, a vague idea that it was a reservation, perhaps at most, as large as Central Park, in which a few well-to-do people had built houses and made of them summer residences; but it was a surprise to find that the park contains more than 4,000 acres of land and water, whose picturesque beauty it would be hard to match anywhere. The ground is rolling, the hills aspiring to the dignity of mountains, all thickly wooded from the valleys to their crests. The roads have been skillfully laid out, and are maintained in excellent condition. The lake is a large, beautiful sheet of water, surrounded with hills between which it reposes in calm placidity, which is restful to look at. Interspersed all through the Park are comfortable and luxurious houses, occupied by numbers of the club or association which is its owner. Altogether it seems an ideal place for a summer residence in which rest and health await the sojourner.

There are two club houses, at one of which the visitors alighted, and were seated on the delightful veranda. Years ago there was an erratic visitor who was an occasional caller at the office of the American Engineer. At the end of one of his visits he inquired of the editor whether he ever "lubricated the amenities of civilized life?" It was his polite way of inviting a person "to take a drink." Now the latter expression is a vulgar one, and therefore the host on this occasion metaphorically invited his guests to indulge in the amenities of civilized life, which the genial band of railroad brethren did while the balmy September breezes fanned their brows, some of which looked as though refreshment both within and without was very grateful.

That the conduct of the party while in the Park was entirely decorous, was evidenced by the fact that a lady—a resident thereof—and who knew nothing of the excursionists, but saw them while they were there—but not while they were on the veranda—reported that she thought it was a band of clergymen.

From the Club House the drive was continued through the Park, and around the lake, via the south gate, and thence by carriage and railroad they visited the Sterling iron mines at Sterling Lake, which the "itinerary" of the excursion said is "the Lake Como of America." These mines have been worked ever since the Revolutionary War, and are entirely subterranean, extending below the bed of the lake. The ores are valuable as mixtures with other ores in the manufacture of some kinds of iron. The ruins of some ancient furnaces which were built some time during the last century, and were operated in Revolutionary days, were pointed out. Lunch was served in a beautiful groove overlooking the lake, and the amenities were again lubricated with ginger ale and—but that is another story.

From Sterling Lake, as the printed "itinerary" poetically expressed it, "through vale and over mountain" the excursionists were taken by rail and carriage to the beautiful home of the Hon. Abram S. Hewitt, which is in this vicinity. The party was received by him and his family with great courtesy, and after other "amenities" had received due attention were conducted over the grounds and shown many very interesting relics of Revolutionary days, which were described by Mr. Hewitt in a way that made the writer regret again—as he has many times before—that writing shorthand was not one of his accomplishments. All were delighted with the visit, and it recalled a popular essay with the title "How to Grow Old Gracefully," which was current twenty-five or thirty years ago. Knowing something of the past career of Mr. Hewitt, the visit suggested that as a prelude to "growing old gracefully," it is essential to live wisely, and that by doing the latter it may be possible when the autumn of life is reached to accept it as gracefully and as graciously as he does.

From his place Mr. Hewitt joined the excursionists, who were taken by carriage and railroad to the Glens of Greenwood Lake, the latter a beautiful sheet of water surrounded by picturesque hills. An excellent dinner was served there with "lubrication." The menu was a work of art, and appealed to the guests aesthetically and gastronomically. After the dinner there were a few short speeches, and much feeling of good-fellowship. From Greenwood Lake the party returned to New York by special train over the Greenwood Lake Railroad, and all united in spirit, if not vocally, in singing "For Snow is a jolly good fellow."

M. N. F.

PERSONALS.

Mr. George W. Seidel has been appointed Master Mechanic of the Lehigh Valley at Buffalo, N. Y., in place of Mr. L. I. Knapp, resigned.

Mr. C. A. Storm has been appointed Mechanical Engineer of the Illinois Central, with headquarters at Chicago, to succeed Mr. E. Grafstrom, resigned.

Mr. Richard H. Relf, Chief Clerk in the Engineering Department of the Northern Pacific, has been appointed Assistant Secretary in place of P. W. Corbett, deseased.

Mr. D. E. Davis has been appointed General Foreman of the Boston shops of the Boston & Maine, and will have entire charge of these shops, to succeed Mr. Hammett, promoted.

Mr. J. W. Marden, heretofore Superintendent of Rolling Stock of the Fitchburg, has been made Foreman of the Car Department of the Fitchburg Division of the Boston & Maine, with headquarters at Boston..

Mr. F. W. Cox, General Foreman of the Locomotive Department of the Chicago, Milwaukee & St. Paul at West Milwaukee, Wis., has resigned, to accept a position with the mechanical department of the Baltimore & Ohio at Baltimore, Md.

Mr. J. D. Murray has been appointed Chief Draftsman of the Car Department of the Delaware, Lackawanna & Western. Mr. Murray has heretofore been connected with the New York Central, and formerly with the Chicago & Northwestern.

Mr. W. F. Beardsley, Master Mechanic of the Northwest System of the Pennsylvania Lines, at Allegheny, Pa., has been transferred to a like position at Crestline, O., in place of Mr. J. D. Harris, who is transferred to Wellsville, O. The latter to succeed Mr. G. P. Sweeley, who is made Master Mechanic, in place of Mr. Beardsley, at Allegheny.

It is officially announced that Mr. P. M. Hammett, Division Master Mechanic of the Boston & Maine, has been appointed Assistant Superintendent of Motive Power of that road. Mr. Hammett was born in 1867., He graduated from Havard College in 1888, and from the Massachusetts Institute of Technology in 1890. He began his railroad service with the Pennsylvania as an apprentice in the shops at Altoona. In 1893 he was appointed General Foreman of the Wilmington shops of the Philadelphia, Wilmington & Baltimore, and three years later entered the service of the Boston & Maine as Division Master Mechanic.

Mr. Robert Rennie has been appointed Master Mechanic of the Pennsylvania Division of the Delaware & Hudson Company with headquarters at Carbondale, Pa., in place of Mr. W. R. Johnson, resigned. Mr. Rennie entered the employ of the Pennsylvania as a machinist in December, 1890, at the Meadow shops and was transferred to the Juniata shops at Altoona in the spring of 1893. While at these shops he worked his way into the Testing Department, where he remained until 1897, when he took charge of the Richmond Tramp Compound for the Richmond Locomotive Works. This position he left after two years to accept the position of General Foreman of the Lehigh Valley, at Easton, Pa.

Edwin M. Bushnell, General Manager of the U. S. Railway Supply Co., died at his home in Brooklyn, Monday, September 24, after an illness of only a week, and at the age of 39 years. The news of his death reaches us as the paper goes to press. He was probably best known in connection with the Bushnell Manufacturing Co., of Easton, Pa., in which he was associated with his father until about two years ago, when he came to New York and organized the U. S. Railway Supply Co. He was a genial, pleasant companion for those who met him in business and knew him slightly. To those who knew him better he was a warm and disinterested friend and to the few who understood him thoroughly his kindly and noble nature inspired the feeling that few men can bring out. He was popular and successful, and will be mourned by many high officials of the railroads as well as others.

TRAVELING ENGINEERS' ASSOCIATION.

At the recent meeting of this association in Cleveland the most important discussions were those on the handling of air-brake trains, the use of the steam engine indicator and smokeless firing.

It was considered advisable to use two applications of the brakes for passenger trains and one long application for freight. For breaking on "double headers" where the use of the air pumps and main reservoirs on both engines is desired it was recommended that the cut-out cock at the brake valve be closed and additional pipe connections made. The parting of freight trains was shown to be a serious matter, particularly when large capacity steel cars were mixed in with lighter cars in trains. The association believed the trouble to be due to weak draft rigging instead of improper handling of the brakes, as is often stated in reports.

The report on the steam engine indicator was noteworthy. It contains a great deal of information about indicator cards and will probably stimulate interest in the indicator, and we hope it will lead to more general use of the instrument.

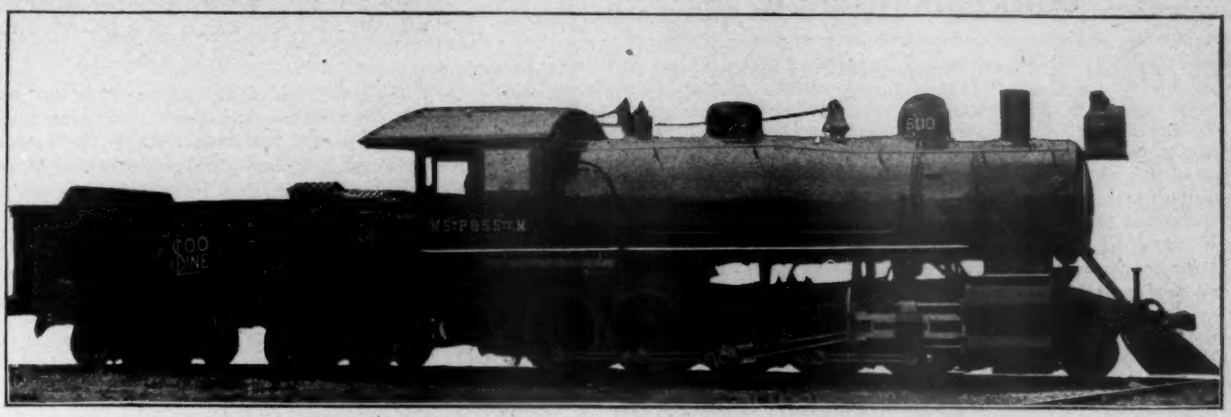
Smokeless firing occupied a large share of attention. The only apparatus needed in order to secure satisfactory results was the ordinary fire-brick arch, but it was often neglected. A brick arch in good condition and light firing were considered all that was necessary. Good results were reported for the form of fire door used on the Southern Pacific. This door has a small opening for the coal and it is always kept open. The small size of the opening made it impossible to fire coal in large quantities. It was shown to be necessary for the higher officers of a road to co-operate in the matter of smoke prevention.

The committee on connections between injectors and locomotive tanks strongly recommended the substitution of large strainers which may be easily removed for the usual conical hose strainer. The holes should not be larger than ⅛ in. in diameter. Injector connections had not been enlarged to correspond with the increased size and power of locomotives, and larger pipes and hose connections were considered necessary. For Nos. 5, 6 and 7 injectors the hose should have an inside diameter of 2 in. For Nos. 8, 9 and 10 it should be 2½ in., and for all sizes larger than No. 10 it should be 3 in.

The meeting was well attended and the discussions were earnest. Mr. C. H. Hogan, of the New York Central, was elected President for the coming year. The next annual convention is to be held in Philadelphia.

Russell snow-plows and flangers of various styles are to be built this fall for the following railroad companies: Boston and Albany R. R., Central Railroad of New Jersey, Chicago, Milwaukee & St. Paul Ry., Delaware, Lackwanna & Western R. R., New York Central & Hudson River R. R., New York, Chicago & St. Louis R. R. and New York, Ontario & Western Ry.

The cast-steel body bolster illustrated on page 291 of our September number was credited to Mr. G. A. Akerlind, Chief Draftsman of the road, who has just informed us that it is the joint production of himself and Mr. J. T. Carroll, at the time assistant in the drawing office, now Mechanical Engineer of the "Nickel Plate."



HEAVY TWELVE-WHEEL FREIGHT LOCOMOTIVE—VAUCLAIN COMPOUND.

MINNEAPOLIS, ST. PAUL & SAULT STE. MARIE RAILWAY. BALDWIN LOCOMOTIVE WORKS, *Builders.*

Weights: Total of engine.....207,210 lbs.; on drivers.....184,360 lbs.; total engine and tender.....327,210 lbs.
Wheel base: Driving.....19 ft. 4 in.; total of engine.....28 ft.; total of engine and tender.....57 ft. 4 in.
Cylinders: 17 and 28 x 32 in. Wheels: Driving.....55 in.; truck.....30 in.; tender.....33 in.
Boiler: Diameter.....68 in.; boiler pressure.....215 lbs.
Firebox: Length.....132 in.; width.....41 in.; depth, front.....77 in.; depth, back.....76 in.
Grate area.....37.5 sq. ft. Tubes: 344, 2 in.; 15 ft. 7 in. long.
Heating surface: Tubes.....2,791.8 sq. ft.; firebox.....223.9 sq. ft.; total.....3,015 sq. ft.
Tender: Eight-wheel; water capacity, 7,000 gals.; coal capacity.....9 tons.

TWELVE-WHEEL COMPOUND FREIGHT LOCOMOTIVE.

Minneapolis, St. Paul & Sault Ste. Marie Railway.

Built by the Baldwin Locomotive Works.

Usually the heaviest freight locomotives are wanted for particular kinds of service, and it is customary to build them to certain definite requirements. The large Illinois Central 12-wheel engine illustrated in our October number last year, page 315, is understood to have been guaranteed to haul 2,000 tons of cars and load over a grade of 35 ft. per mile. The engine of the same type recently built for the Minneapolis, St. Paul & Sault Ste. Marie by the Baldwin Locomotive Works was guaranteed to take the same weight at six miles per hour over a compensated grade of 42 ft. per mile, and this condition was fully met; but the most interesting fact concerning it is the low fuel consumption, which is given in the following table:

Performance Engine 600. August 21, 22 and 26, 1900.

Date.	Distance.	Tonnage Net.	Tonnage Tare.	Tonnage Total.	Cars. Loads.	Cars. Empties.	Ton miles.	Tons coal used.	Lbs. coal per 10,000 ton-miles.
Aug. 21... Ex East	111	1,205.9	790.7	1,996.6	58	0	221,622.6	11.1150	1,044
Aug. 22... Ex West	111 Max.	1,298.8	937.47	2,236.27	60	6	222,782.8	11.425	1,007
Aug. 26...	111	1,227.7	785.05	2,012.75	58	0	223,415.25	10.1450	960

Note.—There are 7 miles omitted on trip of Aug. 26, on account of doubling over a piece of track with a 68-ft. grade.

As this is an opportunity to compare a simple engine with a compound which is guaranteed to do somewhat more than the simple engine, some of the leading dimensions are brought into parallel columns. We do not know the official figures for the fuel consumption of the big Illinois Central engine, but it is rumored that it is not "light on coal." We should think that the advantages of compounding would appear most prominently in such service as this, where the design may be prepared for conditions which seem to be most favorable to this type. The comparison of these figures is to us exceedingly interesting:

	I. C.	"Soo."
Total weight	232,200	207,210
Weight on drivers	193,200	184,360
Size of drivers	57 in.	55 in.
Cylinders	23 x 30 in.	17 and 28 x 32 in.
Heating surface	3,500 sq. ft.	3,015 sq. ft.
Grate area	37.5 sq. ft.	37.5 sq. ft.
Steam pressure	210 lbs.	215 lbs.
Size of boiler	82 in.	68 in.
Tubes, number	424	344
Tubes, size	2 in.	2 in.
Tubes, length	14 ft. 7¾ in.	15 ft. 7 in.

The photograph and the following particulars concerning this design, which is a Vauclain compound, have been furnished by the builders:

General Dimensions.

Cylinders

Diameter (high pressure).....17 in.
Diameter (low pressure).....28 in.
Stroke.....32 in.
Valve.....Balanced piston

Boiler.

Diameter.....68 in.
Thickness of sheets.....11/16 and ¾ in.
Working pressure.....215 lbs.
Fuel.....Soft coal

Firebox.

Material.....Steel
Length.....131 15/16 in.
Width.....41¼ in.
Depth.....Front, 77⅞ in.; back, 76 in.
Thickness of sheets.....Sides, 5/16 in.; back, 5/16 in.; crown, ⅜ in.; tube, ½ in.

Tubes.

Number.....344
Diameter.....2 in.
Length.....15 ft. 7 in.

Heating Surface.

Firebox.....223.9 sq. ft.
Tubes.....2,791.8 sq. ft.
Total.....3,015.7 sq. ft
Grate area.....37.5 sq. ft.

Driving Wheels.

Diameter, outside.....55 in.
Diameter of center.....48 in.
Journals.....Main, 9½ by 12 in.; others, 8½ by 12 in.

Engine Truck Wheels

Diameter.....30 in.
Journals.....6 in. by 10 in.

Wheel Base.

Driving.....19 ft. 4 in.
Rigid.....19 ft. 4 in.
Total engine.....28 ft. 0 in.
Total engine and tender.....57 ft. 4 in.

Weight.

On drivers.....184,360 lbs.
On truck.....22,850 lbs.
Total engine.....207,210 lbs.

Tender.

Diameter of wheels.....33 in.
Journals.....5½ in. by 10 in.
Tank capacity.....7,000 gals.; 9 tons of coal

BACK NUMBERS OF M. C. B. REPORTS.

Back volumes of the proceedings of the Master Car Builders' Association may be had from the Secretary, Mr. J. W. Taylor, except for the years 1873 to 1879, inclusive, and for the year 1891. The reports previous to 1895 were bound in paper and will be furnished at 75 cents per copy. Beginning with 1895 they were bound in cloth, for which the price is $1.50 per copy. The Secretary offers an opportunity for members and others to secure a large number of the back volumes.

CORRESPONDENCE.

THE MODERN ROUNDHOUSE—WHAT IT OUGHT TO BE.

To the Editor:—I have been much interested in the article, "The Modern Roundhouse—What It Ought to Be," which appeared in your August issue, page 245. In general, I think it an excellent article and one which if followed would mean a higher standard of efficiency for the locomotive, and it would increase the output of the repair shop.

How many of the smaller, overcrowded shops of even our large roads would prove amply large enough to care for one, two or even three more engines per month were the class of repairs known as roundhouse repairs faithfully attended to at the roundhouse? The poor roundhouse foreman must not be blamed for all, for how many roundhouses at important centers could we visit to-day and either find no tools or some which should have been in the scrap heap long ago, together with other conditions which are not only costly to maintain, but which are really a disgrace, and yet from these, good work and well-kept engines are expected.

It seems to me the same reason as put forth by Mr. Whyte in a short note in your September issue (and also expressed in the report) as to heading engines into the erecting shop holds true in roundhouse practice, but I do not agree with this committee that when engines back out they will be cleaner. This may be a minor point, but assuming that we have three adjacent pits with three clean engines (rather a bold assumption). The center one starts to back out; naturally the cylinder cocks are opened and the discharge from these as well as from the stack is kindly shared by the adjacent engines and from the moment the stack leaves the smoke jack overhead until outside the house the conditions are the same.

I think dirt floors in roundhouses where work is to be done should be replaced by some such material as suggested.

I hardly agree with the recommendation that all pipes should be overhead, one reason being that which the committee themselves put forth a little further on in the article, for the use of hot air—namely, to have it delivered from the side walls of each pit, where it will be "most effective in thawing out engines that have come into the house covered with snow and ice." Why should not the same reason and position (on the side walls of each pit) hold good for steam pipes? Heated air rises and overhead steam pipes, unless much larger than need be, otherwise will not heat the roundhouse as well as in the pits, and with the doors open a goodly share of the time the overhead pipes, unless well protected, which is not what you want for heating, are very apt to leak, due to the rapid changes in temperature in the surrounding air currents, and then whatever is below derives the benefit from this leakage. Certainly my experience has been that pipes with the proper pitch to care for condensation and properly attached to the walls of each pit will prove superior in service. The first cost is much less, which appeals in many cases to those in authority, and where spare engines are kept ready or considerable time elapses between runs the engines can be coupled up to this piping system and a saving made by so doing.

For the equipment I would include a good forge for use in repairing or straightening brake rods, etc.

There are two points not touched on at all in this report, one of which appeals to me as important, the number, location, height and equipment of the benches. Should they be along the outer wall at intervals or between the pits? Also engineer closets, what about them? I would also like to have the committee's opinion on the best material for smoke jacks or hoods.

I have in mind other suggestions, but would like to see a discussion started from the above, as that means finally all the points for a thoroughly equipped roundhouse.

G. E. MITCHELL, Mechanical Engineer.

New York, September 4, 1900.

In speaking of the relative cost of the present electric and the former steam power for the "Alley L" road of Chicago, Mr. Frank J. Sprague stated before the American Institute of Electrical Engineers that the saving in coal alone is $500 per day.

FLEXIBLE STAYBOLTS IN INDIA.

Effect on Life of Firebox Sheets.

To the Editor:

I observe in your excellent journal on page 382 of the number for December last an interesting paper on staybolt progress. I, however, decline to permit you to give Mr. F. W. Johnstone, of the Mexican Central Railway, the credit for the invention of the flexible stay therein attributed to him. It is possible that he has contributed his quota to bringing up the design to what it now is; but honor should be given to whom honor is due.

If you will refer to "The Engineer" (London), in one of its issues of November, 1879, you will find a most interesting paper on the subject, showing how this system was first invented

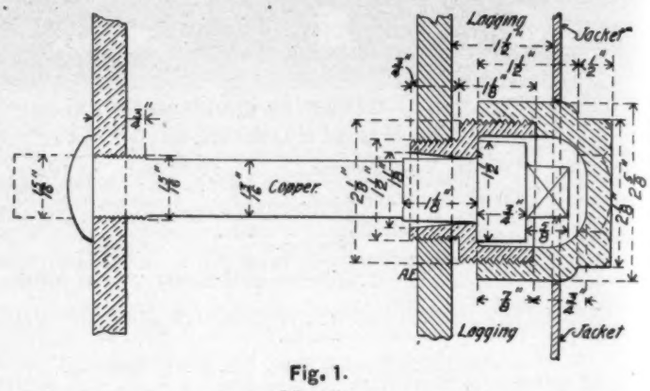


Fig. 1.

and put into practice by Mr. Wehrenfennig, the then Chief Engineer of Material and Traction of the North-Eastern Railway of Austria. I am not aware whether he be still in the land of the living.

Some time subsequent to 1882 the Wehrenfennig system of flexible staying was very much improved upon by the late Mr. W. Leach, the Foreman Boiler-maker of the Rajputana-Malwa Railway of India. He made and patented great improvements in the system, which has been applied on that railway to many hundreds of boilers with the greatest success and immense economical advantage. The water on that railway in some parts is so bad (being heavily charged with magnesium sulphate) that in years gone by I have known new engines with rigidly stayed fireboxes to have their tube plates entirely renewed in less than 12 months from the time they began to run. Since the Leach stay was adopted such disastrous failures are a thing of the past.

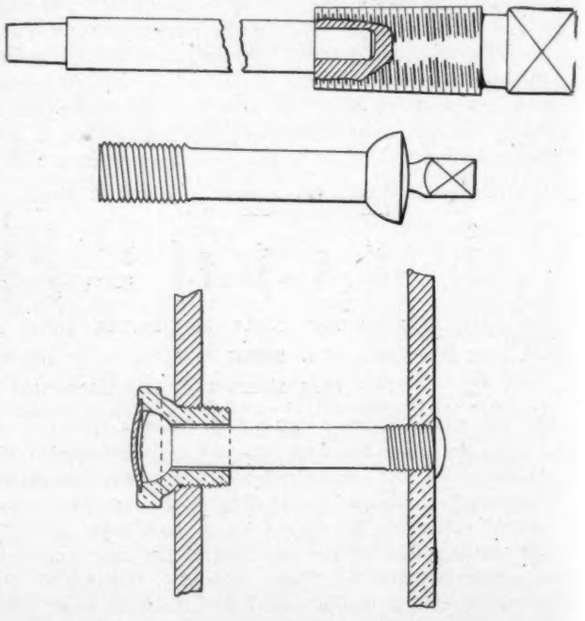


Fig. 2.

I applied Wehrenfennig's system to an old firebox of an en-

gine in India (Central Provinces) in 1882. The tube plate was good but the holes in it were distorted and oval. The bridges were intact but could not have lasted much longer without cracking. I did it as a severe test of the ease to be afforded to that tube plate by flexible staying. In 1894 I learned that that firebox was still running and no further repairs done to it; the tube plate being in just the same condition. The engine had in the interval been in the hands of strangers 2,000 miles away from me and there had been no jockeying or coddling of the tube plate.

In 1893 I fitted a couple of new fireboxes to boilers on the Burma Railways with the Leach stay. Since then they have run about 107,000 miles each without costing anything for repair to the staying or plates.

I enclose ferrotypes of both Wehrenfennig's and Leach's stays which need no explanation.

CORNELIUS E. CARDEW, M. Inst. C. E.,
Locomotive and Carriage Superintendent,
Burma Railways, Insein, Lower Burma.

[Wehrenfennig's staybolt is made as shown in Fig. 1. The Leach staybolt is shown in Fig. 2. The ends of the staybolts at the outer shell are formed with ball heads fitting sockets in brass bushings. The holes in the shell for these bushings are bored with a special boring tool. The holes are then tapped with a tap having a guide bar fitting the holes in the firebox sheets. The bushings are screwed in place and after the holes in the firebox sheets are tapped the stays are screwed up to their seats by the square ends. These ends are left and a sledge is held against them in the riveting, after which they are cut off. The stays are then completed by the insertion of the copper caps. These caps are punched to form from the sheet, and they are forced into place by a small hand screw press which is held under the heads of the bushings. The press flattens the cap slightly and forces the edge into the groove in the bushing, making a tight joint. The drawings kindly sent by Mr. Cardew fully illustrate the construction and the application of these staybolts, which are used for crown as well as side sheets. We are glad to record this successful experience which tends to show how few things are really new. Mr. Cardew gives valuable testimony to the worth of flexible staybolts in prolonging the life of the firebox. We believe that this result will repay a large investment in this direction.—Editor.]

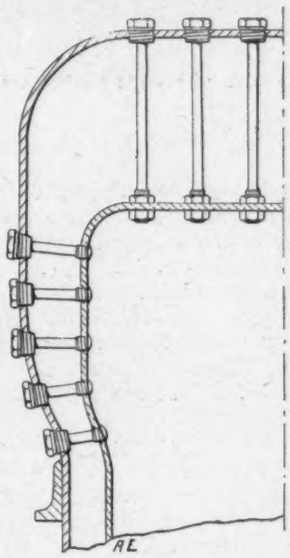


Fig. 3.

A SUGGESTION FROM SWISS PRACTICE.

To the Editor:

On page 290 of your September number is an article entitled "A Suggestion from Swiss Practice," and as I hold letters patent for the United States, Canada, Great Britain and France covering the practice, I do not feel flattered that it required effete Europe to bring to the attention of American railway officials what I have been importuning them for years to try.

In the New England States the writer is facetiously entitled "Spring-Suspension Graham," and the man who dared to say that the equalizer of locomotives was an antiquated relic which possessed no mechanical or other features to entitle it to a place upon a modern locomotive.

You have done the combination of leaf and spiral springs justice in stating that the arrangement is "attractive." Well, it is attractive, for the Czar of Russia and the President of France use it on their private trains. The International Sleeping Car Company of France have adopted it and we have shipped electric trucks all over the world fitted with this arrangement of leaf and spiral springs.

Although the device is attractive, no one but myself (on my own trucks) has had the courage to use only axle-supported springs. Others have been licensed to use it but have neutralized the advantages by using full elliptical bolster springs, which are entirely unnecessary.

Just one exception to your statement where you say: "The wheel beam must be strengthened." Quite the contrary; the entire truck frame can be considerably reduced both in weight and parts.

I have repeatedly stated in the technical papers, in my circulars and before the New England Railroad Club, that the spring-maker's art as applied to moving vehicles is a decided failure, and, if were permitted, I could build a four-wheel truck that would carry any car, no matter what the weight or speed, and would make a pair of them weigh less than one ordinary six-wheel truck.

I thank you most heartily for all you have said in favor of Swiss, or, more properly, my own, practice.

JOHN HECTOR GRAHAM.

Boston, September 19, 1900.

SPEEDS OF FREIGHT TRAINS.

The relation between speeds and the work which may be had from locomotives is shown in a novel way by Mr. F. P. Roesch, in a recent number of "Locomotive Engineering," under the caption "Economy of Speed." The road referred to presented the following conditions (quoted from the discussion):

"A road or division of 150 miles; engines with 20 x 24-in. cylinders and 60-in. driving wheels, capable of hauling 800 tons over the division at two-thirds stroke at an average speed of 10 miles per hour, or 700 tons at one-third stroke at an average speed of 17½ miles per hour."

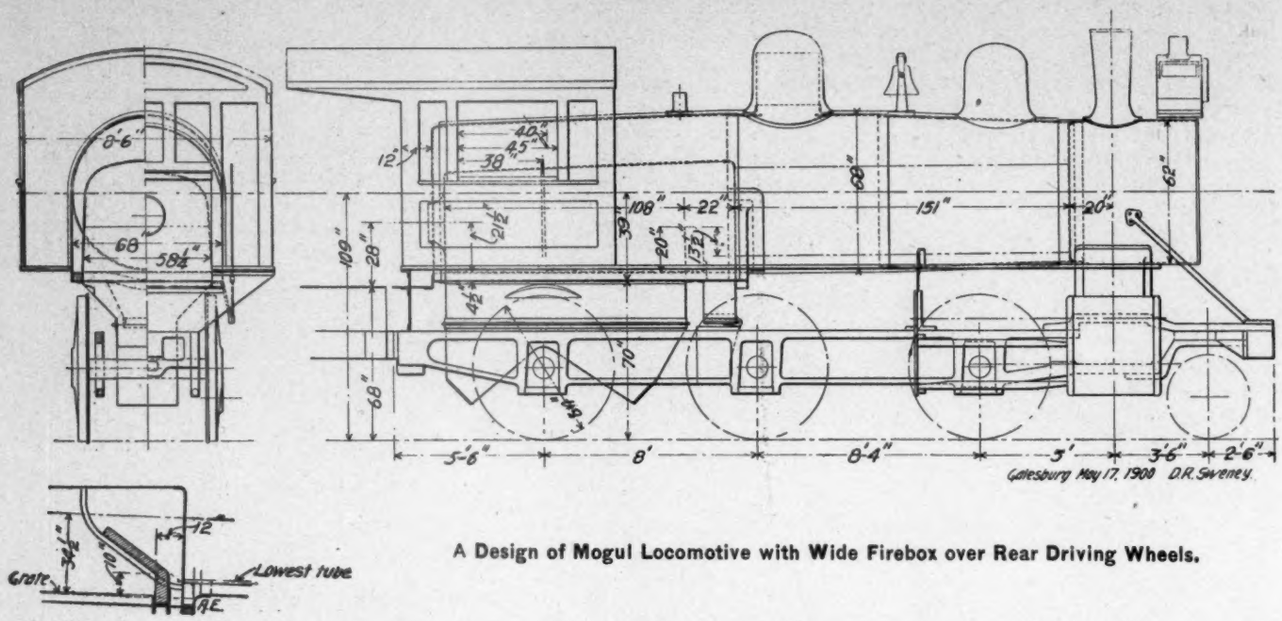
Combining two of the engines, which will be designated No. 1 and No. 2, we may give engine No. 1 a train of 800 tons and No. 2 one of 700 tons. Eliminating the fact that No. 2 with the lighter train can make better meeting points than No. 1—which is giving No. 1 the better of the argument—and assuming that each train can pass over the road without interruption, we find that No. 1, running at the rate of 10 miles per hour, occupies 15 hours in going over the division, while No. 2, whose speed is 17½ miles per hour, uses 8½ hours to go the same distance, a saving of 6½ hours in favor of No. 2.

As engines on arrival at terminals generally require more or less work before going out again, Mr. Roesch allows each engine 7 hours for necessary repairs. Starting both trains from the same terminal, at the same time, we find that No. 2 is ready for the return trip 30 minutes after the arrival of No. 1, and at the end of 24 hours we find that No. 2 is again at the other end of the division, while No. 1 has made but 20 miles on the return trip.

Mr. Roesch then compares the ton miles for the two engines for 24 hours and shows that there is an advantage of 54 per cent. in the lighter trains and higher speed of No. 2. Allowing the same number of hours at the terminals, the train crew wages should be the same for both trains, and allowing $1.35 per hour for the wages of the train crews, the charges in each case would be about $23.

It is well understood that heavy grades affect the relation between fuel consumption and speed and on a hilly road the fuel cost would go up rapidly with the speed, but on a level on nearly level road the difference in speeds considered in this case would surely not adversely affect the fuel consumption, and if the cut-off of engine No. 2 is 8 in. and that of No. 1 half or two-thirds stroke the coal per ton mile would be less for No. 2. If the men are paid for units of 100 miles run, however, the figures of cost per ton mile change materially, although the advantage in the amount of freight handled by an engine remains with the one running at the higher speed.

There seems to be no doubt that in some cases engine ratings have been so large that the cost of repairs have been greatly increased. Up to a certain limit this is economical because of the larger ton mileage of service, but when carried to the point of keeping engines out of service a day or so at a time for repairs the limit of economical loading may soon be passed. The importance of moderately high speeds in saving delays on sidings has probably been underestimated. In many cases, especially on single track lines, the ability to get out of the way of other trains is more important than any other consideration in this discussion. We believe that there is a tendency toward slightly higher speeds in ordinary freight service.



A Design of Mogul Locomotive with Wide Firebox over Rear Driving Wheels.

DESIGN FOR MOGUL LOCOMOTIVE WITH WIDE FIREBOX.

By D. R. Sweney.

In the May issue of the American Engineer you illustrate a locomotive study by Mr. Grafstrom. He has presented a rather difficult problem, viz., an 8-ft. grate above 80-in. driving wheels and the center of the boiler 109 in. above the rails. The inside of the mud-ring is about 7 in. above and 21 in. outside of the wheel flanges. An ashpan located in the rear would require the use of blowers to keep the ashes from accumulating under the grates above the wheels. Too much care cannot be given to the design of ashpans to be used where the runs are long and the coal of a poor grade.

The method which he presents for compelling the gas and flame to traverse a sufficient distance before entering the flues is worthy of study. If you will examine the usual design of combustion chamber which extends into the barrel of the boiler and count the number of stays, you will find it about equal to the number required by the same length of firebox. The recent designs of anthracite burners would undoubtedly make efficient soft coal burners by putting in a bridge wall, as Mr. Grafstrom suggests and which I believe has been done before.

The arrangement which he presents shows the tendency of designers to try to make use of a very large grate area. Nothing can determine the proper area of grates for the use of soft coal so satisfactorily as experience, and the design must be developed step by step. It is reasonable to suppose that to add to the area of grate common on western roads, the first 15 sq. ft. would be of three times the value of a second 15 sq. ft., especially when the present area is so small that there is danger of the draft tearing up the fire. Experience seems to show that the screenings from many mines cannot be burned to advantage on long runs on any area of grate possible on a locomotive, and in such localities it would not be desirable to make the grate larger than necessary to burn mine-run coal with reasonable economy.

The use of the very large grate introduces some objectionable features into the design. If, however, these objections are such as to retard its introduction and it is possible to obtain three-fourths of the desired size without so many undesirable features, why not assume that three-fourths of a good thing is better than one-half and use it. The three-fourths might be found sufficient and would certainly direct the course for further development. It would seem wise in this, as in all experiments, not to introduce any more new and experimental details than are necessary to get the one desired end.

A change from the narrow grate between the wheels to a wider one above the wheels adapted to soft coal requires attention to the following points: (1) method of supporting the boiler and stiffening the frame toward the back end; (2) the height to which it is advisable to carry the boiler; (3) location of doors, deck, etc., to make convenient and efficient firing; (4) the location of engineer; (5) room under the grates for a good ashpan; (6) means for keeping the fire out of the flues and making the flame traverse some distance before entering the flues.

The accompanying plan of an engine is presented as an attempt to apply a larger grate with as few experimental details as possible. It is developed from a standard freight engine and is similar to the standard in most of its dimensions, which are as follows:

	Proposed engine.	Standard engine.
Boiler pressure	200 lbs.	200 lbs.
Cylinders	19 x 26 in.	19 x 26 in
Drivers	64 in.	64 in.
Heating surface	2,040 sq. ft.	2,040 sq. ft
Grate	108 x 58¼ in.	108 x 40¼ in.
Grate area	43¾ sq. ft.	30 sq. ft.
Firebox at bottom	130 x 58¼ in. or 120 x 58¼ in.	108 x 40¼ in.
Center of boiler above rails	109 in.	96 in.
Driving wheel base	16 ft. 4 in. or 15 ft. 10 in.	15 ft. 2 in.
Grates below lowest tube	6¼ in.	20 in.

The firebox being lengthened toward the rear requires lengthening the driving-wheel base in order to distribute the weight properly. In many other cases the boiler could be set ahead. The method of supporting the boiler and stiffening the frames would be the same as with very wide fireboxes. The height of the center of gravity is less than that of many fast engines and must be well within the limit (which is not a very definite height). If there is room in a cab beside the present form of firebox there would still be room with the wider grates which would not increase the width of the upper part of the firebox, or if there is room in a cab beside the barrel of the boiler there would be room beside a firebox of the same width with vertical side sheets. By narrowing the upper part of the back end of the firebox, as is the usual practice with narrow grates, there would be still more room at the point most needed. This design does not need to affect the form of the upper part of the firebox and the manner of staying. The ashpan under a 5-ft. grate will require less room above the wheels than that for an 8-ft. grate. The bridge wall and the arrangements in front of it are subjects for experiment. The height which it is necessary to make the wall and

the distance which it should be located from the flue sheet are unknown, but experiments to determine this would not be expensive. By the use of arch tubes the box could be shortened 10 or 12 in., as the bridge wall could be low and an arch extended from its top at an incline backward as is usually done from the flue sheet.

It is interesting to study the adaptability of this form of firebox to some recent large freight engines. In many cases an increase of 40 to 45 per cent. of grate area could be obtained without any increase in the length or weight and with a reduction in the number of short stays and curves.

TABLE OF THICKNESSES OF BOILER SHEETS.

By F. K. Caswell.

Where many calculations have to be made from the same formula it often pays to adopt short methods, and I have prepared a table and description of the way of making it which may be of interest to the readers of the American Engineer.

The formula for the safe thickness of plates for circular courses is $t = \frac{F P D}{2 S \%}$ in which:

t = thickness of steel.
F = factor of safety.
P = maximum working pressure.
D = internal diameter of the course.
S = tensile strength of plate.
% = strength of riveted joint in per cent. of solid plate.

Only commercial thicknesses of plates are ordinarily used, therefore, if we decide on uniform values for S, % and F, using the lowest allowable limit in each, we can readily find the largest or limiting diameter for each 1/16 in. in thickness and each pressure.

By transposing, our formula now becomes $D = \frac{t\,2\,S\,\%}{F P}$ and substituting for S, % and F the values 54,000, .75 and 4 we have $D = \frac{20250\ t}{P}$. From this we can get a constant for each thickness, thus:

t =	5/16	7/16	9/16	11/16	13/16	15/16	17/16	19/16	21/16	23/16
20250t =	7594	8859	10125	11390	12656	13922	15187	16453	17718	18984

By dividing each constant by the various pressures we can make a table of limiting diameters as given below, or by dividing by given diameters we can get the limiting pressure. The table given is used as follows:

Example I.: What thickness is required for a 64-inch course to carry 200 lbs. pressure?

In column 200 we find 64 in. between 63¼ in. and 69 9/16 in. or over 5/8 in., therefore the next regular thickness, 11/16 in., should be used.

Example II.: What pressure can be carried on a 62-in. boiler 9/16 in. thick?

On line 9/16 in., 63¼ in. diameter can carry 180 lbs., therefor, 62 in., being smaller, is good for 180 lbs. or a little more.

Thickness of Boiler Courses.

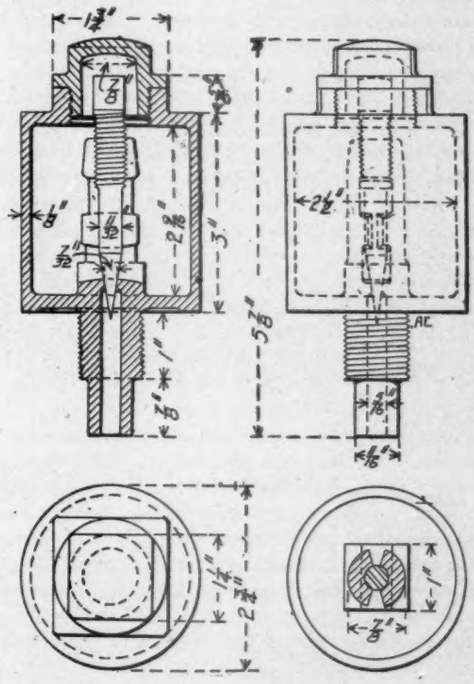
Pressure....	150	160	170	180	190	200	210	220	240
Limiting diameters (inside).									
Safe thickness (inches). 5/16	50 5/16	47 7/16	44 5/16	42 1/16	39 13/16	37 11/16	36 1/16	34 1/16	33
7/16	59 3/16	55 5/16	52 1/16	49 3/16	46 5/16	44 1/4	42 3/16	40 1/4	38 1/16
9/16	67 1/16	63 1/4	59 1/16	56 1/4	53 1/4	50 1/16	48 1/16	46	44
11/16	75 11/16	71 3/16	67	63 1/4	59 11/16	56 11/16	54 3/16	51 15/16	49 1/4
13/16	84 5/16	79 1/16	74 7/16	70 5/16	66 7/16	63 1/4	60 1/4	57 1/16	55
15/16	92 11/16	87	81 7/16	77 1/16	73 1/4	69 5/16	66 1/4	63 1/4	60 1/4
17/16		94 7/16	89 1/16	84 5/16	79 7/16	75 5/16	72 1/4	69	66
19/16				91 3/16	86 1/16	82 1/4	78 1/16	74 5/16	71 1/4
21/16					93 1/4	88 1/16	84 5/16	80 1/4	77
23/16						94 7/16	90 5/16	86 1/4	82 1/16

The above figures are for steel of 54,000 lbs. per square inch tensile strength: riveted joint of 75% efficiency and a factor of safety of 4. Use maximum working pressure.

MALLEABLE IRON OIL CUPS.

Central Railroad of New Jersey.

Oil cups for main and side rods and other parts of locomotives are important beyond all proportion to their size. They are often made of brass, and have brass covers. The loss of the cover while running means a hot pin, and the loss of the entire cup and cover by thievery is a common occurrence which is explained by the present high price of copper and brass. The brass covers often become lost and they are usually replaced by tin; on one road, the New York Central, pressed steel is being considered for covers for cups where the covers may be slipped on without requiring a screw cap for security. For rods, malleable iron oil cups have been used for several years, and they are satisfactory in every way. The form illustrated was put into use on the Central Railroad of New Jersey about a year ago. It is cheap, efficient and looks well. The



Malleable Iron Oil Cups.

interesting features are the long tube at the bottom which takes the oil down into contact with the crank pin, the form of the base whereby a secure fastening to the rod is obtained and an excellent device for regulating the flow of oil. In many cups the tube at the bottom terminates with the threaded portion and this permits the oil to pass between the brass and the rod, while this long tube carries each drop down upon the pin itself. The form of the bottom of the cup is seen in the sectional views. It is thinned down in such a way as to obtain the assistance of the elasticity of the bottom of the cup to hold it against turning back after it has been screwed down firmly. To this feature Mr. McIntosh attributes the entire freedom from loss of the cups by unscrewing. The regulating needle is held in a split clamp in which a portion of the hole is bored four one-thousandths of an inch smaller than the needle. The friction thus obtained holds the needle where it is adjusted. It is the intention to use this regulating device on all oil cups put into use in future because of the advantage of using but one form of feeding device.

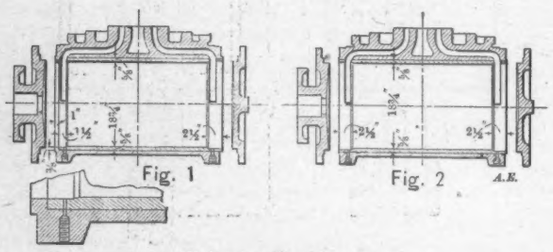
CYLINDER BUSHINGS.

By F. E. Seeley.

One of the questions asked by the committee of the Master Mechanics' Association, appointed to ascertain to what extent the standards and recommendations of the association are being carried out, relates to the use of bushing in cylinders. Out of about 50 replies to circulars sent out in this connection only half report as to the use of cylinder bushings at all, and the majority of these use them to only a very slight extent; the rest report no experience at all in the matter. They offer advantages which are perhaps not fully appreciated.

The use of bushings provides a way to reduce the bore of a cylinder and furnishes an excellent method of repairing worn and cracked cylinders, as well as a remedy for cylinders which are too soft to provide a good wearing surface. Probably no two practices agree precisely as to the method of applying bushings to worn cylinders and it will be worth while to discuss briefly one of the best.

After allowing, say, a 19-in. cylinder to wear ¾-in. in diameter, or to 19¾ in., it is rebored to 1 in. larger diameter—that is, to 20 in.; then a bushing 20 in. outside diameter and ⅝ in. thick is inserted, bringing the diameter of the cylinder to ¼ in. less than normal size, or to 18¾ in. Ports corresponding in size and location with those in the cylinder are cut in the bushing, cylinder cock holes are tapped, and the bushing is counterbored as would be the cylinder. Some practices call for a bushing whose outside diameter is 1/100 in. greater than



Cylinder Bushings.

the inside diameter of the cylinder, but in most cases they are made the same size with good results. To insert the bushing it is necessary to heat the cylinder. This may be conveniently done by placing hot bars of iron, of about the length of the cylinder, on pieces set across the cylinder a little below the center so that the heat may be uniformly distributed. When the cylinder has expanded sufficiently the bushing is put in. This must be done as quickly as possible, as the bushing being thin expands immediately on coming in contact with the hot cylinder, and little time is allowed for adjusting. The cylinder and bushing cooling together make a nice fit, and when the front head is put on there is very little possibility of the shifting of the bushing. A pin, however, is sometimes inserted through the cylinder and bushing near each end to insure against movement.

It may be well to mention two of the most common ways of fitting bushings. Both have given perfect satisfaction and both have their advocates. One method is shown in Fig. 1. As the cylinder wears and is rebored, an inch ledge is left untouched at the back end of the cylinder. The diameter of a 19-in. cylinder at this point would thus remain 19¼ in. (assuming the counterbore to be ¾ in.). When the cylinder is finally rebored to 20 in. for a bushing, this inch ledge, which is now ⅜ in. high, furnishes an excellent face against which to drive the bushing; in which case the bushing is counterbored an inch less at the back than at the front end. In this method the wearing face for the back head is not destroyed and there is consequently one less chance for leakage.

In the second method, as shown in Fig. 2, the bushing is made the full length of the cylinder. It is driven up against the back head, and held there by the front head. This requires a little more care, but makes a nice job and seems to be the method most generally adopted.

The use of bushings is, however, not by any means confined to worn and cracked cylinders. There are several advantages in the application of bushings to new cylinders which it will be well to consider. A good cylinder casting should possess two qualities: First, the body should be strong and tough to withstand the sudden and variable strains to which it is subjected. Second the wearing face should be hard in order to secure a good polish and furnish a good durable wearing surface. In a single casting these two considerations are directly opposed to each other, and in providing for one the other is neglected, and in a compromise between the two the best results are not obtained. In providing the necessary softness for the first the wearing surface is sacrificed, frequent reboring is necessary, and the friction between the cylinder and piston is increased. In providing the right degree of hardness for the second the casting is rendered less tough and not as well adapted to stand the excessive strain. Frictional resistance between the cylinder and piston consumes a large amount of power, and by the use of a bushing harder than can be obtained in an ordinary cylinder casting a decided economy in the above respect is produced.

It thus seems that, as in the case of false valve seats, the best results will be obtained when the body and the wearing face of the cylinder are made in separate pieces and each piece is designed and made to best meet the particular conditions to which it is to be subjected.

The largest floating dry dock in the world has recently been purchased from the Spanish Government by the United States for the sum of $250,000. This dock was built for the Spanish Government in Birkenhead, on the Mersey, England, in 1897, at a cost of nearly $600,000, for use in Havana Harbor. It is 450 ft. long, 82 ft. wide, weighs 4,400 tons, and has a lifting capacity of 10,000 tons. The operation of the structure is comparatively easy, and is accomplished by hydraulic power. The dock is divided into a series of water-tight compartments on each side of the keel, called the load balance, and air chambers. These are distinct from each other. When docking a man-of-war they are filled with water, which sinks the dock to a depth of 27½ ft. The ship is then brought over the blocks and centered, after which the water is pumped out and the dock rises, lifting the ship. This new dock will be placed at Pensacola, Fla.

A substantial application of 38 miles of automatic block signals is being made on the Chicago end of the Chicago & Alton Railroad. There will be 43 home and 50 distant signals of the semaphore type, operated by electric motors which are controlled by track circuits. The signals stand nominally in the horizontal position and the distant signals will be cleared when the trains arrive at a point about 1,200 ft. from them, so that the enginemen will be able to see the signals go to the clear positions. The distant signals will use yellow lights when horizontal. All switches within the limits of the application are connected with the signal circuits so that an open switch will put the signals to "danger" in that portion of track in which the open switch causes danger. At the switches bells are located and these will ring upon the approach of trains as a warning against opening the switch before the train has passed. It is a very complete system of automatic signaling, the noteworthy feature being the use of automatic electric semaphores.

Mr. F. A. Barbey, 185 Summer Street, Boston, has been appointed representative of the Standard Pneumatic Tool Company for the New England States.

NEW FILLING VALVE FOR PINTSCH CAR EQUIPMENT.

An improvement in the filling valve for the car equipment of Pintsch apparatus has been developed and tested and is now ready for application in place of the old valves. Its purpose is to more thoroughly control the possible leakage around valve stems when filling the receivers, thus preventing the escape of gas. The new valves are made in accordance with the improved design, which is illustrated in the accompanying engravings.

The bonnet fits the regular valve body (known as No. 65) and the cover (known as No. 89) needs only a new bonnet cap,

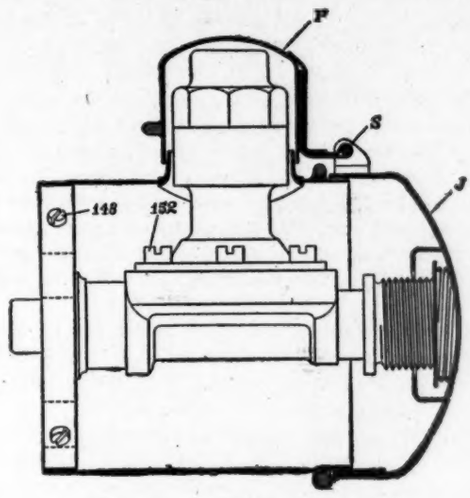


Fig. 1.—Filling Valve and Cover.

P, to make it applicable to the new valve. The valve carrier, L, has a square extension on the bottom of which the disc, O, is placed. This extension passes through the square opening in the bottom of the bonnet, N, to prevent the carrier from turning. The valve stem, K, is held between the valve-stem nut, M, and the packing nut, R. The packing, Q, is forced more tightly by turning the packing nut, R. It will be seen that the valve carrier may be removed and new one substituted by simply removing the packing nut, R. The pitch of the threads on the packing nut, R, and the bonnet, N, is the same

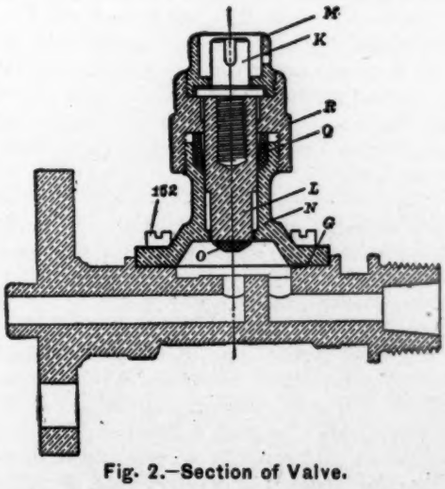


Fig. 2.—Section of Valve.

as on the valve stem, K and the valve carrier L, therefore tightening R on N will not jam the valve. To place the cover on the valve it is necessary to remove the packing nut, R.

In accordance with the custom of the Safety Car Heating & Lighting Company such improvements as this are always submitted to long-time tests in regular service, and it is now brought to the attention of the railroads with the hope that all valves in use will be rapidly changed.

IMPACT TESTS.

Metals which adjust themselves under the pull of the tensile test and hold up to the requirements for strength and elongation are by no means always able to transmit and distribute the vibrations which are set up in the outermost parts of the metal by the impact test.

Dr. C. B. Dudley, Chemist of the Pennsylvania Railroad, gave, in response to a request from the committee appointed by the American Section of the International Association for Testing Materials, his judgment in the matter of impact tests as follows:

"We are getting more and more experienced all the time, we are constantly trying to test material just as we put it in service, rather than a piece of it; that is to say, we test a whole axle rather than a piece cut out of it; we test a whole carwheel, rather than a fragment of it, and so on. Obviously, for this purpose either very large testing machines are required or else we must use the impact test. We have accordingly expanded quite a little in recent years in impact testing, and with the construction of machines which the Pennsylvania Railroad requires, we are inclined to think that the impact test is a genuine, scientific test, provided, of course, that deflection is taken as one of the elements. In our judgment impact testing will continue to increase."

Dr. R. Moldenke, Superintendent of the Pennsylvania Malleable Company, in answer to the same committee, said that the impact test was a most important one, because the majority of finished materials fail through vibration or shock. The heaviest breakages in couplers, guardarms excepted, is in the lugs. An inspection of tens of thousands of these breakages would give an impression that they were all pulled off, and yet close investigation reveals the fact that 80 per cent. were first battered up by impact and then pulled through the cracks. Here is explained the tendency to call for high tensile strength, when really what is wanted is high resistances to impact. The railroads are, with hardly an exception, using the impact tests in buying axles and automatic car couplers. There is also in the minds of some the idea of testing bolsters by these tests, which, in Dr. Moldenke's opinion, is a good step toward keeping materials up to the proper standard.

PIECE WORK VS. PREMIUM PLAN.

The distinction between the premium plan and ordinary piece-work is consistently and continually urged by the "American Machinist." Mr. F. A. Halsey, whose name is prominent in this connection, recently answered a correspondent through its columns with the following clear statement of the fundamental differences between the two systems:

No employer can contemplate paying the same wages cost per piece for his product 10 years from now that he does today. He must contemplate and expect a steady reduction of these costs. With piece-work this can only be brought about by cuts in the piece prices, with demoralizing effects. It will thus be seen that while these cuts are, from the workman's standpoint, the embodiment of injustice, they are, from the employer's standpoint, a matter of necessity.

Piece-work professes to give the employee all the gains due to his efforts, but in fact does not do it, because of these repeated cuts, which cannot be avoided. The premium plan promises less to the workman, but carries out its promises. Under any system it is impossible that the workman should in reality receive all the gains due to increased output, because that means stationary wages cost to the employer.

The chief merit of the premium plan is that a steady reduction in cost is brought about automatically, without any change in the agreement under which the employee works.

FLANGE WEAR OF CAR WHEELS.

Excessive flange wear of freight car wheels becomes more troublesome as wheel loads increase and the increasing amount of discussion of the reasons for it indicate its importance.

A careful review of the subject suggests the necessity for looking to the character of the trucks with reference to their ability to hold the axles in parallel, the importance of having on each axle, wheels of equal diameters, the ability of the bolsters to keep the side bearings apart (or the use of roller bearings), the employment of trucks which shall retain their shape and ability to properly perform their functions under the several shocks of service and means for lubricating center plates.

The best recent statement of the truck situation that we now recall is that by Mr. E. D. Bronner, of the Michigan Central. Mr. Bronner said (M. C. B. proceedings, 1898, page 74): "The diamond frame type of truck was a better type for small capacity cars than it will be for those of 60,000, 80,000 or 100,000 lbs. capacity." And also: "From my point of view a plate truck . . . (mentioning a number of pedestal trucks) is the most efficient truck for cars of large capacity. Properly designed and built in the proper manner, with the right material, they will retain their shape in service, thus reducing train resistance and flange wear."

We are inclined to believe that this idea and the other points mentioned cover the flange wear difficulty, and, as Mr. Hubbell said recently before the St. Louis Railway Club, that it is not "the result of any one thing, but the effect of a number of causes." Its effects are to increase the expense of car repairs and to greatly increase the cost of hauling trains on account of the increased train resistance.

The lubrication of center plates is one of the most important factors in this question. It applies to all trucks, whether with roller side bearings or not, and affects the flange wear independently of the character of the bolsters. The effect of lubrication was strikingly shown in our July number in connection with the description of the Dayton center plate.

KRUPP STEEL WORKS.

Probably few appreciate the great extent and large capacity of the Krupp steel establishments in Germany. In a communication from Frankfort, Consul-General Richard Guenther sends the following interesting summary:

The annual report of the Chamber of Commerce for the district of Essen contains statements concerning the cast-steel works of Frederick Krupp. These comprise the following: Cast-steel works, at Essen; Krupp steel works, formerly F. Asthower & Co., at Annen, in Westphalia; the Gruson works, at Buckau, near Magdeburg; four blast furnaces at Duisburg, Neuwied, Engers and Rheinhausen (this latter consists of three furnaces, with a capacity for each of 230 tons per twenty-four hours); a foundry at Sayn; four coal mines (Hanover, Saelzer, Neuack and Hannibal), with interest in other coal mines; more than 500 iron mines near Bilbao, in northern Spain; shooting grounds at Meppen, with a length of 10⅝ miles and a posibility of extension for 15 miles; three ocean steamers, several stone quarries, clay and sand pits, etc. In addition, the firm of Frederick Krupp operates the Ship and Machine Stock Company Germania, at Berlin and Kiel, under contract.

The most important articles of manufacture of the cast-steel works at Essen are cannon (up to the end of 1899 38,478 had been sold), projectiles, precussion caps, ammunition, etc.; gun barrels, armor plates and armor sheets for all protected parts of men-of-war, as also for fortifications; railroad material for shipbuilders, parts of machinery of all kinds, steel and iron plates, rollers, steel for tools and other purposes. The steel works in 1899 operated about 1,700 furnaces, forge fires, etc., about 4,000 tool and work machines, 132 steam hammers of from 200 pounds to 5,000 metric tons force, more than 30 hydraulic presses (among them 2 of 5,000 tons each, 1 of 2,000 tons and 1 of 1,200 tons pressure), 316 stationary steam boilers, 497 steam engines with an aggregate of 41,213 horse-power, 558 cranes of from 400 to 150,000 tons lifting power. During the last year the iron mines yielded an aggregate of 1,877 tons of ore per day. The coal production from the mines belonging to the Krupp Company (excepting the Hannibal) amounted, on an average, to about 3,738 tons for each working day.

The consumption of coal and coke in 1899 was as follows: In the cast-steel works at Essen, 952,365 tons; in the other works and on the steamers of the company, 622,118 tons; in all, in round numbers, 5,000 tons per day. The consumption of water at the cast-steel works in 1899 was 15,018,156 cubic meters, which equals about the consumption of the city of Frankfort with 229,279 inhabitants. The consumption of gas in the steel works at Essen was 18,836,050 cubic meters in 1899.

The electrical power plant of the works at Essen has three machine houses with six distributing stations, and supplies 877 arc lights, 6,724 incandescent lamps and 179 electric motors.

For the traffic of the works, railroad tracks of standard gauge of about 36 miles, are laid, which connect with the tracks of the main railroad station at Essen. Sixteen locomotives and 707 cars are operated on the grounds. In addition there are narrow-gauge tracks of 28 miles, with 26 locomotives and 1,209 cars.

The telegraph system of the steel works has 31 stations, with 58 Morse telegraphic instruments and 50 miles circuit. The telephone system has 328 stations, with 335 telephones and a circuit of 200 miles.

On April 1, 1900, the total number of persons employed in the different works was 46,679, viz., 27,462 at Essen, 3,475 at the Gruson works of Buckau, 3,450 at the Germania works at Berlin and Kiel, 6,164 in the coal mines and 6,128 at the blast furnaces and on the testing grounds at Meppen, etc.

Illustrated Catalogue of the "Four Track Series." The passenger department of the New York Central & Hudson River Railroad has found it necessary to issue a catalogue of their publications. It is in the form of a 40-page illustrated pamphlet and will be sent free to any address on receipt of a 2-cent postage stamp by Mr. Geo. H. Daniels, General Passenger Agent, Grand Central Station, New York.

A surprising prediction by Mr. Nicola Tesla concerning long-distance electric transmission was recently included in an interview with the inventor printed in the New York "Sun." He is reported as saying: "The limitation which we still have to contend with is the loss in the transmission to a distance, and this, I hope, with my latest improvement, to do away with almost entirely, and I think that the time is not far off when we shall be able to transmit with wires buried in the ground, power from Niagara to New York City, with a loss not exceeding one-half of one per cent."

James Ball, an engineer on the Kansas City, Fort Scott & Memphis, has just resigned, after almost 49 years' service in a locomotive cab. He is 68 years old, and said to be the oldest engineer in the United States in the matter of uninterrupted service. The New York "Commercial" states that in spite of his age he was able recently to pass a satisfactory examination for sight and hearing. His retirement was voluntary. Mr. Ball's record is of unusual interest. At the age of 20 he was firing an engine on the Cleveland & Pittsburg, and in 1855 became a locomotive engineer. Three years later he was employed on the New Orleans & Western, and in 1861 entered the Government service, having charge of the engine that pulled the last train of Federal troops from the scene of the second battle of Bull Run, and nearly losing his life. This was on the Alexandria & Orange. In 1862 he was on the Erie, and later went to the Central Pacific. His connection with the Memphis began in 1878.

GOOD STAYBOLT PRACTICE.

The opinion from the extensive experience of Mr. Archie Baird, foreman boilermaker of the A. T. & S. F. Ry., upon the best methods of fitting locomotive staybolts is summed up in the "Railway and Engineering Review" as follows:

In new boilers, keep under 4 in. centers in spacing; that is necessary to maintain about double the factor of safety in the staybolted portion over that of the cylindrical parts of the boiler, and adds greatly to life of bolts.

When the renewal of a firebox becomes necessary, do not have too many different sizes of bolts. If it is found that the casing sides will tap out part ⅞ in., 15-16 in. and 1 in., it is the better way to make the box 1 in. throughout.

Under no circumstances use a staybolt to exceed 1 1-8 in. diameter. Bush the casing side rather than use a large bolt.

Have the bolts cut so as to show a clean, smooth thread, avoid taper, and see that the bolt does not run out of 12 threads per inch its entire length.

Do not have the bolts made to run into the sheets too tight. An easy bolt run in without strain will give better results than one going in too tight, for the staybolt does not depend on the threads for strength—rather the opposite, for a physical test will make it evident that a plain bolt, put in a plain hole and riveted over like an ordinary threaded staybolt head, will stand from 1,000 to 3,000 lbs. more than the threaded bolt will before pulling through. The thread simply acts as a shoulder to help stay sheets that are subjected to intense heat. Aside from this one feature, the thread on a bolt would not be an actual necessity.

Modern railroading has abandoned the old 5 and 6-ft. boxes, and the old steam pressure of 130 to 150 lbs. per sq. in., in favor of 8 and 10-ft. boxes and 180 to 200 lbs. steam pressure. This change of conditions has come about within 10 years and must be met and looked upon as a very radical change. Of course, we try to hold the safety factor by an increased thickness of plate, rivets, etc., but nevertheless we stand on more dangerous ground than heretofore, and my plan would be not to experiment any longer with the different kinds of double-ended or concave section bolts, but to apply a clean cut, threaded staybolt, made of good, honest charcoal iron. Then to test the boiler every 30 days, and alternate every second bolt with new ones, so as not to exceed 2 years' life for any one bolt in the entire boiler in a bad water section. In a good water section, to renew 5 rows in the offset, 2 top rows and 1 row next to the flanges of the door and flue sheet in the same time. It is my belief that this, in addition to the other recommendations, is the best method of applying staybolts where the best possible life is desired in the interest of safety.

A SCHEDULE FOR APPRENTICES.

On the Chicago & Northwestern Railway two classes of apprentices are taken—regular and special. The first are those who have had but a common school education, and are taken for a four years' course. The latter are those who have had a technical education, and these serve three years.

They have the following course alloted to them:

Regular Apprentices.

	Months
Tool room	3
Machines	15
Erecting floor	12
Rod and vise	6
Laying off	3
Drawing room	6
Test work	3

Special Apprentices.

	Months
Machines	9
Erecting floor	12
Rod and vise	6
Drawing room	6
Test work	3

The time divisions of the schedule are in multiples of three months, and a convenient chart is used, giving at a glance the location of each apprentice in the shop. This is arranged as indicated in the accompanying table, in which each apprentice is represented by an initial. Special apprentices are now taken in July, and these will be placed among the squares in such a way as to distribute them and avoid getting too many together. This plan is described in a brief paper by Mr. G. R. Henderson before the Western Railway Club, which concludes as follows:

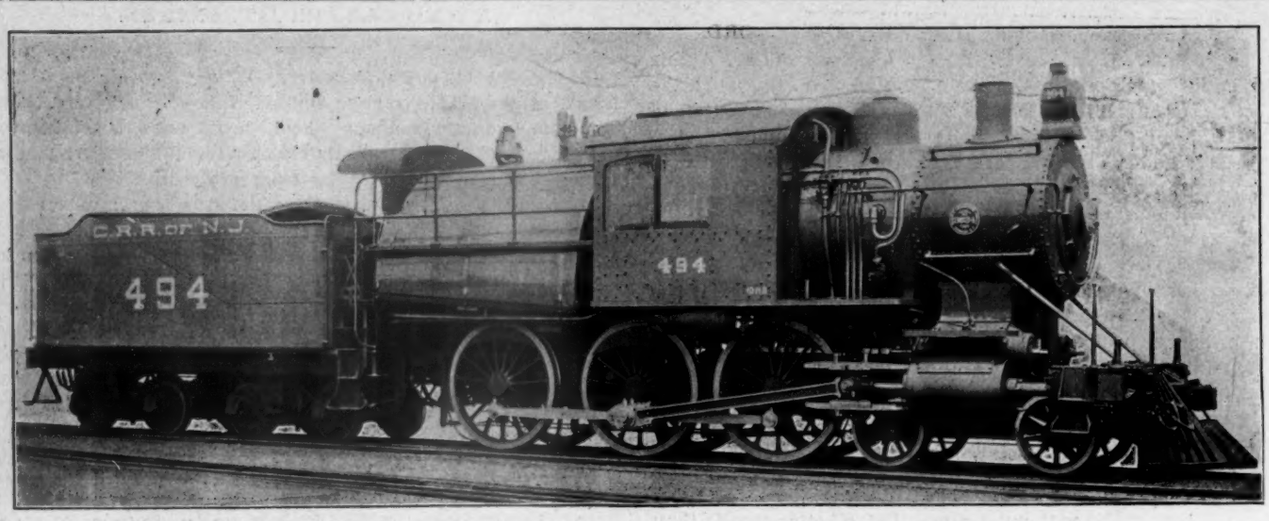
"Of course these plans are not entirely unselfish on the part of the company, as we desire to have thorough mechanics, who will be eligible for promotion, and some of our most promising foremen of the present day are those who have gone through the course in our shops. We look to these for prospective master mechanics. The whole scheme has been outlined with the idea of giving every opportunity for the apprentice to develop into a valuable mechanic, and, later on, an officer of the railroad, provided he has the necessary qualities in him."

Year	1900				1901				1902				1903				1904			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Tool Room	S.T.	T.	V																	
Machines	*M.A.H. K.L.B.N. O.P.Q.R.	I.S.K.N. O.P.Q.R. *B.*A.	F I J K N O P Q R.S.T V W.X.	F I J O R.S.T V. W.X.Y.	F J O R. S. T. V W.X.Y.	S.T V	T.V	V				U	U.	*U						
Erecting Floor	D.I.J.C. P.	C D F.G H.J	C D E G H.U.	C D E G H.K N.P. U.	E.G.H.N. K.P.U.	E.K N.O. P R.U.V. W.	K.N.O.P. R. S. V W.	O.P.R.S. T.V.W.	O.R.S.T. V.Y	S T V	T.X.Y.	X.V.	X	†X †W.						
Rod and Vise	E.G.	E			D.I	†J.X.	O.X.	K.N.	†N P	P R V	O.R.S.	S.T.W.	T W V	†V V						
Laying Off						†I		U.	K	O	P	W	S.	T	V					
Drawing Room				Q	*C.O.	*D G H	*F.H	X	U.X.	K U.W	K V W.	O.P V	O.P	R S	*R.S	*T.V	V			
Test Work						*Q.F	*E.*G.	*H	W	X	U	*K	R V	*O.*P.	T	*S		*V		

NOTE.—* Regular apprentice out of time. † Special apprentice out of time.

Chicago & Northwestern Railway. Schedule of Work for Chicago Shops. Machinist Apprentices.

The Ashton Valve Company, 271 Franklin Street, Boston, have been informed that the Jury of Awards of the Paris Exposition have awarded them three medals, one silver and two bronze, upon their exhibit of pop-valves and gauges, the silver medal being the highest award that was possible to obtain in this class of exhibits.



Ten-Wheel Wide Firebox Locomotive.—Central Railroad of New Jersey.
For Passenger and Fast Freight Service.

TEN-WHEEL, WIDE FIREBOX LOCOMOTIVES.

Central Railroad of New Jersey.

Built by the Brooks Locomotive Works.

This road has received a number of wide firebox locomotives of the 10-wheel type from the Brooks Locomotive Works for fast freight service, the design being such as to render them equally well adapted to heavy passenger service. They have piston valves and tender water scoops, and when tried on passenger trains of the Long Branch & Point Pleasant Division they gave very satisfactory results. They are now running on this division, and Mr. McIntosh speaks very highly of their work.

The grates are a combination of water tubes and shaking bars of the Yingling type, which have been very successful in stationary practice. Instead of the usual rocking arrangement these shaking grates are placed so that the fingers of adjacent grates interlock and grind the cinders so that they will pass down through. The fingers are made small in section to prevent burning. The tenders carry 5,000 gallons of water and 12 tons of coal, which is fine anthracite, used extensively on this road. We have the following items from the specifictaions:

Total weight	174,500 lbs.
Weight on drivers	132,000 lbs.
Weight on trucks	42,500 lbs.
Total of tender and engine	274,500 lbs.
Boiler pressure	210 lbs.
Cylinders	20 by 28 in.
Driving wheels, outside	69 in.
Diameter of boiler, front end	70 in.
Firebox	123 by 97 in.
Heating surface, firebox	174 sq. ft.
Heating surface, tubes	2,338 sq. ft.
Heating surface, total	2,512 sq. ft.
Grate area	83.3 sq. ft.
Tubes, number	325
Tubes, diameter	2 in.
Tubes, length	13 ft. 10 in.
Driving wheel base	13 ft. 6 in.
Engine wheel base	24 ft. 9 in.
Total wheel base	50 ft. 9 in.
Valves	Brooks, piston
Fuel	Fine anthracite

A new, and probably popular, rule regarding uniforms for passenger trainmen has been adopted on the Chicago & Alton. The company will present one new uniform each year to each employe who obeys the rules strictly and who has held the same position in the employ of the road for five years. Two uniforms—one winter and one summer—will be given annually to each employe who has held the same position for ten years.

COST OF MAINTENANCE OF EQUIPMENT.

As in these days all of the problems in the science of transportation—even those that are purely mechanical—must be solved in the clear light of net earnings, the question of the money cost of maintenance of equipment becomes of interest to the heads of the department. One important line, the Atchison, Topeka & Santa Fe, shows categorically in the annual reports the average cost of repairs and renewals per locomotive, per passenger car and per freight car. Perhaps others do likewise. The practice is admirable and might well be extended.

Possibly some have not seen the latest statement of the average cost of equipment maintenance, and will be interested in a brief summary of the facts. The figures are to be found in the returns to the Interstate Commerce Commission, and are given here as they appear for the four years, 1895-98, inclusive. The averages are obtained, of course, by division of the amounts reported to have been expended under each head for repairs and renewals by the number of locomotives, passenger cars and freight cars, respectively. Here are the figures for the United States:

Average Cost of Maintenance of Equipment.

	Each Locomotive	Each Passenger Car.	Each Freight Car.
1895	$1,070	$450	$34
1896	1,200	484	42
1897	1,090	466	36
1898	1,245	499	44
Average, four years	$1,151	$475	$39

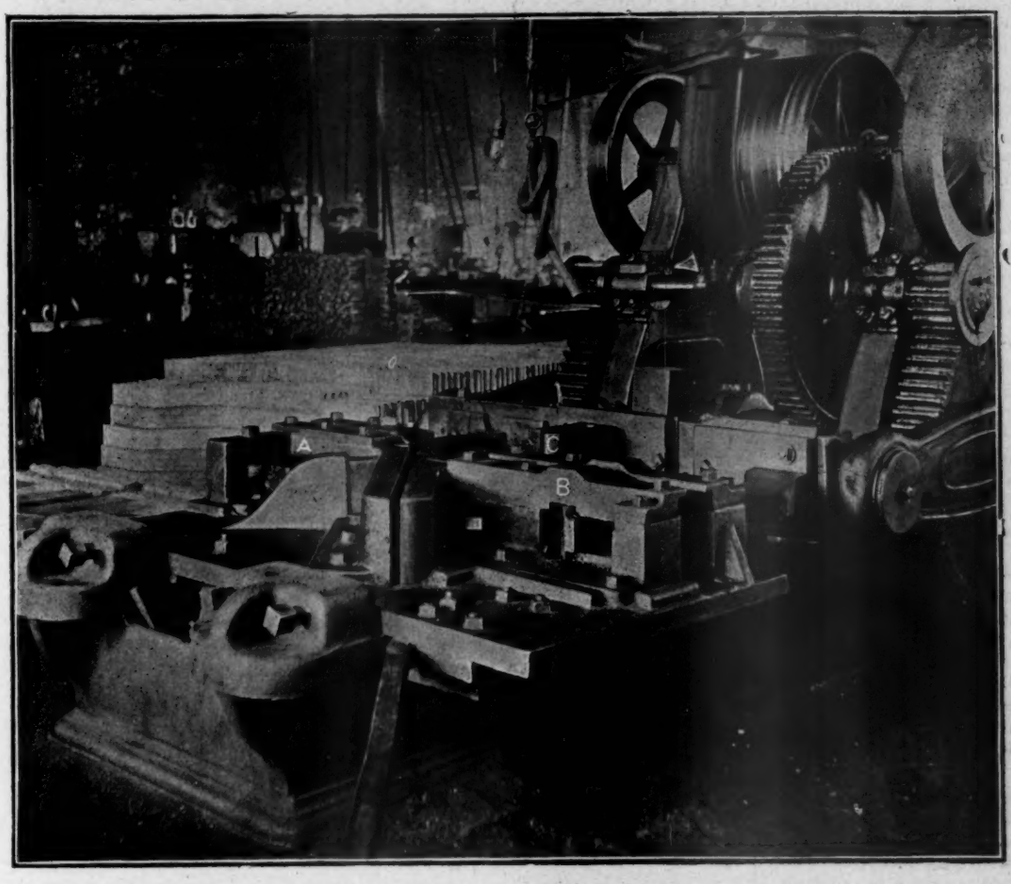
Considering the fact that, in the hard times of 1895 and 1896, maintenance of equipment was avowedly slighted to a considerable extent, the showing for 1898 presumably is nearer actual normal requirements than that for 1895, for example. On the other hand, many roads make special appropriations of revenue for the benefit of the equipment department without carrying the money through the operating expense accounts.

All things considered, therefore, perhaps the figures given in the table for 1898 may be accepted as a reasonable estimate of the average annual cost of the maintenance of the equipment of the American railways, or, say, in round numbers, $1,250 per locomotive, $500 per passenger car and $45 to $50 per freight car. On this assumption, if the averages run higher than these, the real earning power of the road is concealed to that extent, while if they run lower the management may be called on justly by financial interests to prove that the property is not being allowed to deteriorate.—"The Railway Age."

A BULLDOZING MACHINE WITH A RECORD.

C. M. & St. P. Railway.

The bulldozing machine illustrated in the accompanying engraving performs by the aid of ingeniously arranged dies 125 different operations in car forgings and a large percentage of locomotive forgings. This machine has been in constant service in the West Milwaukee blacksmith shop of the Chicago, Milwaukee & St. Paul Railway for nearly eight years, and the only repairs that have been made during this time have been the occasional planing down of some heading tools used in connection with the male dies, which must necessarily wear in time from constant friction upon the work. Formerly this work was done on the anvil, but with the increased output of box and stock cars, which now averages fifteen a day, too many forges would be required and the time spent by the blacksmiths and their helpers in waiting for the iron to be brought to the proper heat would nearly equal that spent in actual work upon the forgings. With this machine and a properly designed furnace, nine or ten forges are displaced, which is not only a saving in floor area, but a large saving in the number of men required to turn out a given amount of work.



The machine is known as Williams, White & Co.'s No. 5 Standard Bulldozer, and is well suited for heavy work. From the engraving it will be seen that the live head is moved to and from its work by side rods, which are in turn operated by two pairs of large and small gear wheels driven from an overhead shaft. Suitable bed-plates are used in connection with the female dies and bolted to the frame of the machine, while the male dies are bolted to the live head.

One of the more complicated operations is performed by the dies shown in the engraving. They are used in turning down the ends of the tension members of body bolsters. The movements of the live parts of the female die are at right angles to the path of the male die and receive power from two heavy tongues bolted to the head of the machine and work through slots in the die housings and dies. The curved-out line of these tongues has a cam action that gives the required length of stroke to the dies as the tongues are forced through the slots.

The various operations performed by the machine can all be managed by three or four men. One operates the machine and two, and sometimes three, tend to the furnace and to feeding the machine. The slabs are taken from the furnace, dropped on edge between two loose-fitting guides and against the stop on an adjusting rod, part of which is shown in the engraving. The guides, one of which is fixed with reference to the other, are placed at an angle of 45 degrees with the bed-plate of the female die. The reason for putting the work in at this angle is to give the male die more pressing action upon the work.

With the first movement of the live head the side dies close up on the work and the die, which moves in the housing marked A in the engraving, bends the end of the metal over the round corner of the die, moving in housing B from an angle of 180 degrees to about 50 degrees. Further movement of the live head withdraws die B and the bend is completed by the die C, which flattens it back upon itself. The die A acts at this time as a support to the hot metal during the completion of the bend. These reference letters may be seen by close examination of the engraving.

For such work as the compression members of body bolsters, carry irons and arch-bars for trucks, the female dies have no live parts and the only movement is that of the male die on the live end. These operations are simple and are all performed in one heat. When the metal to be operated on is heated throughout, as in the case of arch-bars, the furnace is filled with from 110 to 150 slabs, and heated at one time.

This is one of the most useful machines in this shop. It is used by Mr. Hennessey as a part of an extensive system of labor-saving tools, which contribute to the plan of building freight cars whereby the road builds them cheaper than they can be bought.

BOOKS AND PAMPHLETS.

Proceedings of the American Railway Master Mechanics' Association Thirty-third Annual Convention. Held at Saratoga, N. Y., June, 1900. Edited by Jos. W. Taylor, Secretary of the Association.

This volume, as usual, contains the constitution, lists of officers and members, and the proceedings of the convention. It is uniform in binding with other recent volumes, and is, as usual, ready for distribution at a remarkably early date after the close of the convention. This volume contains a specially valuable list of subjects treated by the association since the first meeting, with the important reports and decisions indicated in heavy type. We also note that in a number of the reports marginal captions have been used. This is an improvement which will be greatly appreciated by those who have occasion to refer to the proceedings.

Universal Directory of Railway Officials. Published by the Directory Publishing Company, Limited, 8 Catharine Street, Strand, London. Sole representative in the United States, E. A. Simmons, 697 Chauncey Street, Brooklyn, N. Y. Pages, 563. Price, $2.50.

This is the sixth annual edition of this valuable publication. It contains a list of the officials and information concerning the gauge, mileage and equipment of the railways of the world. It includes a convenient alphabetical finding list of the officials and is printed in a convenient style. This year the portion of the list concerning South African roads is not offered as accurate because of the effects of the war, but otherwise the information is offered as official. It is compiled by S. Richardson Blundstone, editor of "The Railway Engineer."

Proceedings of the Western Railway Club. Vol. 12, 1899-1900. Published by The Western Railway Club, 667 Rookery Building, Chicago, 1900.

This is the only railroad club placing before the members the proceedings of the year in a bound and indexed volume. No better method of expending its money can be imagined, and we think it much wiser to increase the value of membership in this way than to indulge in frequent lunches and an annual dinner, which seems to be growing in popularity in other railroad clubs. The money expended in these affairs, which are, of course, very enjoyable, would seem to be better invested in the way the Western Club has practiced for two years. The volumes resemble the form adopted by the M. C. B. and M. M. Associations, and the proceedings under notice are worthy of a place beside those of the national organizations.

The Work of Railroad Men on the Problem of Pure Water for Steam Boilers. By C. Herschel Koyl. Reprinted from the Railroad Gazette.

This little pamphlet is issued by the Industrial Water Company, 15 Wall Street, New York. It contains a review of the reports and discussions at various times before the Master Mechanics' Association upon the purification of feed water. The chief deduction from the reports is that water should be treated before it goes into the boiler. At the end of the pamphlet appears a statement by the Industrial Water Company concerning their apparatus for continuously and automatically purifying water, the total cost of operation of which, including interest on the plant, is stated at five cents per thousand gallons or less. The cost is contrasted with that of the average damage to locomotive boilers, which was placed by the Master Mechanics' Association at about fifty cents per thousand gallons. It is a good investment to buy water for locomotives at thirteen cents, a common price for city water, but a still better one to provide water better than ordinary city water at a cost of from four to five cents. This company invites those having trouble with boiler waters to send gallon samples of the water with a statement of the amount used per day and they will estimate the cost of purification. This is a most important subject. Bad water not only increases the cost of repairs, but it is also expensive in keeping locomotives out of service for the repairs and for the regular washings.

Railroad Construction, Theory and Practice. By Walter Loring Webb, Assistant Prof. Civil Engineering, University of Pennsylvania. Published by John Wiley & Sons, New York, 1900.

Notwithstanding the numerous hand-books that have been issued on railroad curves, location and computation, this book gives the essentials of alignment and location in as concise and satisfactory a form as the best of them, leaving out much of the useless material that litters up some of the hand-books. On the subject of construction, however, the work is in many ways deficient. It is necessarily a compilation of data and designs, but it omits much that might be looked for in such a publication. On the subject of culverts and arches, for example, structures of concrete and of concrete and steel in combination are entirely omitted, although the most conservative engineers will admit that these types are coming to play a most important part in the economy of railroad construction. The discussion on tunnel practice contains but little of modern methods. In earthwork, the book summarizes much of the already existing information and also adds a great deal that is new and useful in approximate methods of computation. And the cost of moving earth is treated more comprehensively probably than in any other existing text. For contractors interested in the cost of excavating, hauling, and filling this book contains probably the most satisfactory treatment of the subject, whether for railroad work or general construction. Finally, the book contains numerous logarithmic, trigonometric and curve tables, as well as functions for transition curves and tables for estimating road work or general construction. The book containing what has hitherto been found only in widely scattered texts, and has added much original material. The book occupies a field that has been treated by other authors only in a fragmentary way.

The John Davis Company, 51 Michigan Street, Chicago, have issued a new catalogue of steam fitters' supplies, wrought iron pipe, tools, including almost every conceivable item which may be wanted in connection with steam piping or heating systems. It is compact in form and its 294 pages are filled with everything that one would look for from a firm supplying the wants of steam users. It is indexed and the prices of nearly all the specialties are given.

Drop in Alternating-Current Lines.—The Westinghouse Electric & Manufacturing Company have issued in good form a pamphlet entitled "Drop in Alternating-Current Lines," which is a reprint of an article by Ralph D. Mershon, which treats of a method for calculating drop in alternating circuits. This pamphlet is supplemented by a short illustrated description of the Westinghouse Type F compensator, which records at the power station, without the use of pressure wires, the voltage delivered to the load regardless of the nature of the load. The description also includes tables for setting and instructions for the adjustment of the instruments.

Electric Power.—A very handsomely illustrated catalogue has been issued by the Westinghouse Electric & Manufacturing Company showing some of the many ways in which the Westinghouse electric motors are used for industrial purposes. The book does not give a description of the motors, but simply a caption, explanatory of the service to which that particular motor is applied, and depending on the excellent collection of 61 half-tone engravings for telling the story. The printed matter is in four languages, French, English German and Spanish. The catalogue is intended for distribution at the Paris Exposition.

"Three Points of View" is the title of a compact presentation of the merits of the turret lathes manufactured by the American Turret Lathe Company, Wilmington, Delaware. It is in the form of a well-illustrated pamphlet, showing the advantages of their "semi-automatic" turret lathes from the standpoint of the proprietor, the superintendent and the operator. The proprietor is interested in securing great output at low cost; the superintendent is chiefly interested in the "driving" power, which enables him to make a good showing, and in large output per man employed; while the operator desires a convenient machine which will enable him to make good wages without undue physical strain. These three views are really one, and the pamphlet is very successful in conveying the impression that these manufacturers have good ideas and that they have embodied them in their machines. They have no hesitation in guaranteeing what the lathes will do.

The Jeffrey Manufacturing Company, Columbus, O., have prepared a new and completed catalogue of chains which is ready for distribution and will be sent on request.

The Phosphor-Bronze Smelting Company, Limited, 2200 Washington Avenue, Philadelphia, have sent out their revised Phosphor-Bronze Price-List No. 17, which presents lists of the various forms of this metal which they are prepared to furnish.

"Some Words of Wisdom About Paint" is the title of a little pamphlet received from the Joseph Dixon Crucible Company, Jersey City, N. J. It is printed in the interests of the well-known graphite paint manufactured by this company and shows its qualifications as a protective covering for roofs.

The General Society of Mechanics and Tradesmen, 20 West 44th Street, New York, has added a new department to its library for current catalogues connected with machinery, building and machinery supplies of all kinds. The catalogues will be kept on file carefully indexed and made accessible at all times to those who may care to consult them. Machinery concerns are requested to send their catalogues to the librarian at the address given above.

The Springfield Gas Engines.—The Springfield Gas Engine Company, of Springfield, O., have issued a 32-page catalogue of their gas engines in which the designs are illustrated in detail by aid of half-tone engravings. Their unusual simplicity is strikingly shown. A number of illustrations of important plants employing these engines are included. The engravings are excellent and the pamphlet is adapted to the wants of busy men.

Hydraulic Tools.—Watson-Stillman Company have just issued another of their subdivided catalogues, No. 60, illustrating and describing hydraulic tools used by jewelers and die-sinkers. Each page contains an engraving of one of these machines and a carefully prepared description, together with a short table of weights, pressures and prices of that machine. This company makes a very large line of high-pressure hydraulic tools for all purposes and has exceptional facilities for the making of special tools and machinery.

The Knecht Brothers Company, Cincinnati, O., designers and builders of special machinery and tools, have prepared a pamphlet of eight pages describing their friction sensitive drill, which is considered an indispensable machine by those who use it. It is described in this pamphlet, dimensions and details of weight and capacity being given. In a number of testimonials we find letters from Mr. Howard M. Smith, Master Mechanic of the Terminal Railroad Association of St. Louis, and from Mr. H. A. Gillis, Superintendent of the Richmond Locomotive Works, commending it highly. Mr. Smith uses the machine as a centering machine as well as a drill press. We have already directed the attention of our readers to the design and construction of the machine in our pages.

Catalogue of the Niles Tool Works.—This book of 169 pages is the handsomest work of the kind we have seen. It is bound in flexible morocco and was prepared for distribution at the Paris Exposition. The descriptions are in French, English and German, the three languages being used in parallel throughout the book. The dimensions are given in metric and English measures. The machines are presented in the following groups: Railroad machinery, lathes, pulley, planing, slotting and shaping machines, boring and turning mills, horizontal boring and drilling machines, cylinder boring machines, drills and boiler shop tools. The engravings, which are remarkably fine, also include a number of views of some of the largest machine shops in the world in which the product of these works is used. The catalogue compels admiration in itself. It must convey an impression of the high character of the Niles Tool Works even to those who may not know of this in other ways, and none but a successful concern could produce such an exhibit of its work. As a piece of good printing and handsome, tasteful catalogue literature, it has not been equaled by any we have seen.

EQUIPMENT AND MANUFACTURING NOTES.

The Ajax Metal Company have secured the services of Mr. J. G. Miller to represent them in Chicago and the Northwest. His office is in the Marquette Building, Chicago.

The Rand Drill Company have received recognition from the Paris Exposition for the high character of their machinery in the form of the grand prize and gold medals.

Mr. Nat C. Dean informs us that he has severed his connection as representative of the Carbon Steel Company, but will continue his connection with the railway paint business of The Lowe Brothers Company.

The locomotives of the Chicago, Rock Island & Pacific and the Rio Grande Western railways, illustrated last month, were equipped with Ashton Muffler, pop safety valves furnished by the Ashton Valve Company, 271 Franklin Street, Boston.

Mr. J. W. Gardner has resigned as General Sales Agent of The Sargent Company, Chicago, to become associated with Mr. E. C. Darley, General Western Agent of the Aultman & Taylor Manufacturing Company, Mansfield, O., manufacturers of the Cahall vertical and Babcock & Wilcox water-tube boilers.

The Pressed Steel Car Company have received an order for 70 steel ore cars of 80,000 lbs. capacity for the Great Southern Railroad of Spain. This is the first use of steel cars in that country. They are to be of the type used in the United States, except that one car in each train, or seven cars in the lot, will have a timber shelter for the use of brakemen.

The Ashcroft Manufacturing Company, 87 Liberty Street, New York, have been informed that they have been awarded a medal at the Paris Exposition for locomotive steam gauges. In view of the fact that France is the home of M. Bourdon, the inventor of the Bourdon spring steam gauge, this is a high compliment to American enterprise.

The Richmond Locomotive and Machine Works have just received an order from the Intercolonial Railway of Canada for ten consolidation locomotives with 56-in. drivers; weight in working order, 164,000 lbs., with 147,000 lbs. on drivers. The boilers are of the straight-top type, 66 ins. in diameter at the smokebox end, and will carry 200 lbs. steam pressure. Five of the engines will be compounds, with 22½ and 35 by 30-in. cylinders.

Mr. C. H. Howard of Schickle, Harrison & Howard, St. Louis, has patented a new brake gear for railroad cars which is decidedly novel. It is an arrangement of a hollow cast-steel bolster into which are incorporated the air-brake cylinder and triple valve in such a way as to avoid the use of brake beams and all levers and the usual rods. Near each end of the bolster is a cylinder with two pistons, each piston being coupled to a brake shoe. The cylinders are between the wheels and the motion to the shoes is direct. It is an exceedingly ingenious arrangement.

A convention of salesmen of the Magnolia Metal Company, at which twenty-five gentlemen from all parts of the United States and Canada were present, was held at the Murray Hill Hotel, New York, on the 6th to the 10th of September, and subjects appertaining to the sale of Magnolia Metal were discussed, the greatest interest in the business of the company being manifested. Reports for all concerned showed that the business had never, during the past fifteen years, been so prosperous as during the last year and a half, and that the prospects for the future are far better than ever before. The utmost enthusiasm was shown by all for Magnolia Metal and for the future of the company and the affair wound up by the presentation of a loving cup to Mr. E. C. Miller, Vice-President and General Manager.

The Babcock & Wilcox boilers have been awarded the "Grand Prix" at the Paris Exposition. This is a pleasing recognition of the merits of the products of this firm, and a satisfactory support of the principle of water-tube boilers.

Among the awards announced at the Paris Exposition is that on pneumatic tools, bestowed on the Chicago Pneumatic Tool Company in the form of a gold medal, the highest and, so far as appears from the printed reports, the only award made on this class of machinery. In addition to this gold medal, Mr. Joseph Boyer, of St. Louis, the inventor of the Boyer Pneumatic Hammer, Boyer Pneumatic Drill and other tools made by this company, was also given a gold medal. There were several competitors striving for this prize and the recipients of the honors feel highly gratified at the result.

In a recent communication to the Bullock Electric Manufacturing Company, Messrs. Geo. A. Fuller Company, contractors for the Broadway Chambers Building, New York City, a model of which is exhibited at the Paris Exposition, say: "Your dynamo forms a prominent feature in our exhibit, and helped to obtain the grand prize and gold medals which have been awarded to this exhibit." Prospective purchasers would serve their own interests by investigating the Bullock dynamos and motors before placing their orders. Descriptive and illustrated bulletins furnished free upon request to the Bullock Electric Manufacturing Company, St. Paul Building, New York City.

Prominent among the representative machinery concerns of the country who have carried off high honors at the Paris Exposition is the Shaw Electric Crane Company of Muskegon, Michigan, manufacturers of the celebrated Shaw three-motor electric traveling cranes, for machine and railroad ships, shipbuilders' and boiler makers' use. Word has just been received by Messrs. Manning, Maxwell & Moore, the sole sales agents of the Shaw Electric Crane Company, that the International Jury of Award has awarded the Shaw Electric Crane Company a gold medal in Class 21, General Mechanical Apparatus, and a silver medal in Class 23, Electrical Appliances for Hoisting. The awards show a gratifying recognition of the superior merit of the Shaw cranes and bespeak an increased demand for them abroad.

The recent discovery of Goldschmidt, that aluminum in powder form is one of the most powerful reducing agents known, has attracted widespread attention. It is possible by this means to reduce the most refractory oxides and produce such metals as chromium, tungsten, molybdenum, manganese and nickel, perfectly free from carbon and in the fused state. This is possible because of the enormous heat produced by the chemical reaction of the aluminum upon the various oxides. The heat so produced is estimated at about 5,000 deg. and can be equalled only in an electric furnace. With considerable interest we learn that the Ajax Metal Company, of Philadelphia, have acquired a similar process for producing the alloys of these metals with iron, and so low in carbon and silicon as to meet all the requirements of steel makers, but of a far more inexpensive re-agent. Ordinary carbon steel castings can be made by this process in the crucible or on the open hearth. The castings so produced are so low in carbon as to almost approach malleable iron and require no annealing. The Ajax Metal Company intends to manufacture these alloys in ingot form for the use of tool-steel makers and manufacturers of armor plates, projectiles, etc., also to manufacture chrome, nickel and ordinary steel castings of superior quality.

Naturally the competition for recognition of merit at the Paris Exposition is attracting a great deal of attention and the large number of awards granted to Americans is pleasing. The Department of Civil Engineering and Transportation has awarded the grand prize for the convertible open and closed car to the J. G. Brill Company, of Philadelphia. This company also received the grand prize for their complete system of electric trucks. These manufacturers are so well known in this country for the high character of their work that the award is not surprising, but it is encouraging to note the growing appreciation in foreign countries. The convertible car built by the Brill Company for the Leeds Corporation Tramways, which was exhibited at the International Tramway and Light Railway Exhibition in London last June, was considered the most complete and satisfactory convertible car ever built.

The Burlington's new line between Alliance, Neb., and Brush, Colo., was formally opened to general traffic September 15th. The new branch is 149.69 miles long, and is laid with 85-pound steel rails. It will make a short route between Denver and the rich mining districts of South Dakota and Montana. The new line connects with the system's Guernsey extension at Northport, Neb., and practically opens up a new transcontinental railway between Colorado and points in Montana, Washington and the North Pacific Coast. Under previously existing conditions the Burlington's traffic between Denver and the Black Hills was handled by way of Lincoln. The new cut-off will reduce the present distance 673 miles. A passenger is now able to leave Deadwood in the morning and reach Denver the same night. The new line will be of marked importance to the lumber and shingle interests of the Puget Sound district, as it will open up a new market. This trade is now to a great extent shut off from the Colorado markets because of the long haul.

In the rough and wild, yet picturesque, country of northern New Hampshire known as the White Mountain Region, one finds a wonderful array of scenic splendor, the like of which tourists say cannot be equaled elsewhere.

In this region, which is made up of several distinct mountain ranges, is the noted Franconia Notch and mountains. The principal feature is the profile of the "Old Man of the Mountains." Close by are Profile and Echo Lakes, Cannon Mountain, The Basin, Pool and Flume, each of which one finds to be highly interesting places. Bethlehem and Maplewood are delightfully located, and to them many go in search of a relief for hay fever, which is most always instantly alleviated, for the air is pure, dry and healthful.

Fabyan, Mt. Pleasant, Crawford, Jefferson, Lisbon, Sugar Hill, Colebrook, Lancaster, Ossipee, Bartlett, North Conway, Intervale, North Woodstock and other well-known resorts are the abiding places for thousands of tourists, at each of which places one finds an endless variety of mountain wonders.

Every tourist should visit Mt. Washington, for from that point one gets a complete view and idea of the mountain regions. The trip up the mountain is decidedly interesting. The summit is 6,293 ft. above the sea level, and in some places on the railroad the grade is 14 in. in every 3 ft. From the summit the view is magnificent, in some directions extending more than a hundred miles.

Short trips can be made from the summit. The one to the "Lake of the Clouds" giving one a taste of mountain climbing, while the excursion to Tuckerman's Ravine oftentimes proves to be hazardous and dangerous. The sunrise from Mt. Washington is a most beautiful sight and well worth the journey up the mountain to see.

Beginning September 15th the Boston & Maine Railroad placed on sale at many of its stations reduced rate tickets to the mountains good going not after October 6th (except from stations on Connecticut & Passumpsic and Fitchburg Divisions, sale being discontinued on September 29th). The rate is exceptionally low and if you want to go into the mountain regions under most favorable circumstances send to the General Passenger Department, Boston & Maine Railroad, Boston, for circular of White Mountain Trips.

WANTED.—Two complete volumes of the "American Engineer and Railroad Journal" for 1898, unbound. Will pay $3 each if in good order. Also copies of the "National Car and Locomotive Builder," one of the January and February issues of 1898. Fifty cents will be paid for a complete copy of each. Address L. L. S. and H. B. H., care Editor "American Engineer," 140 Nassau Street, New York.